Federal Aviation Administration – Regulations and Policies
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Engine Harmonization Working Group

Task 19 – Bird Ingestion Part II

Task Assignment

[Federal Register: November 7, 2001 (Volume 66, Number 216)]
[Notices]
[Page 56366-56367]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issues--New Task

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: The **FAA** assigned the Aviation Rulemaking Advisory Committee a new task to review and evaluate the current standards for Sec. 33.14 and corresponding JAR-E 515 as they pertain to the current ``safe life'' process. This notice is to inform the public of this ARAC activity.

FOR FURTHER INFORMATION CONTACT: Timoleon Mouzakis, Federal Aviation Administration, New England Region Headquarters, Engine and Propeller Standards Staff, 12 New England Executive Park, Burlington, MA 01803, phone (781) 238-7114, facsimile: (781) 238-7199, timoleon.mouzakis@**faa**.gov.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** established the Aviation Rulemaking Advisory Committee to provide advice and recommendations to the **FAA** Administrator on the **FAA**'s rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the **FAA**'s commitments to harmonize Title 14 of the Code of Federal Regulations (14 CFR) with its partners in Europe and Canada.

The Task

1. Review and evaluate the current standards for Sec. 33.14 and corresponding JAR-E-515 as they pertain to the current ``safe life'' process. As the existing standards do not explicitly account for the potential degrading effects of anomalous materials and manufacturing or usage induced anomalies, determine if the **FAA** can expand the current requirement to include damage tolerance philosophies. Also, establish

the process to achieve a closed loop system which links the assumptions made in design (by engineering) to how the part is manufactured and maintained in service.

2. Develop a report based on the review, which may include revisions to the rules. If revisions to the rules are recommended, the report should include recommended regulatory language to the appropriate FAR section, the corresponding JAR paragraphs, any related advisory material, and ARAC's response to the economic questions attached to this tasking record.

3. If, as a result of the recommendations, the **FAA** publishes an NPRM and/or notice of proposed availability of draft advisory circular for public comment, the **FAA** may ask ARAC to review all comments and provide the agency a recommendation for the disposition of those comments.

Schedule: Required completion is no later than September 2003.

ARAC Acceptance of Task

ARAC accepted the task and assigned the task to the Engine Harmonization Working Group, Transport Airplane and Engine Issues. The working group serves as staff to ARAC and assists in the analysis of assigned tasks. ARAC must review and approve the working group's recommendations. If ARAC accepts the working group's recommendations, it will forward them to the **FAA**.

Working Group Activity

The Engine Harmonization Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan for consideration at the next meeting of the ARAC on transport airplane and engine issues held following publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations prior to proceeding with the work stated in item 3 below.
3. Draft the appropriate documents and required analyses and/or any other related materials or documents.
4. Provide a status report at each meeting of the ARAC held to consider transport airplane and engine issues.

Participation in the Working Group

The Engine Harmonization Working Group is composed of technical experts having an interest in the assigned task. A working group member need not be a representative or a member of the full committee.

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption FOR FURTHER INFORMATION CONTACT expressing that desire, describing his or her interest in the task, and stating the expertise he or she would bring to the working group. All requests to participate must be received no later than December 7, 2001. The requests will be reviewed by the assistant chair, the assistant executive director, and the working group co-chairs. Individuals will be advised whether or not their request can be accommodated.

Individuals chosen for membership on the working group must represent their aviation community segment and actively participate in the working group (e.g., attend all meetings, provide written comments when requested to do so, etc.). They must devote the resources necessary to support the working group in meeting any assigned deadlines. Members must keep their management chain and those they may represent advised of working group activities and decisions to ensure that the proposed technical solutions do not conflict with their sponsoring organization's position when the subject being negotiated is presented to ARAC for approval.

Once the working group has begun deliberations, members will not be added or substituted without the approval of the assistant chair, the assistant executive director, and the working group co-chairs.

The Secretary of Transportation determined that the formation and use of the ARAC is necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of the ARAC will be open to the public. Meetings of the Engine Harmonization Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. The **FAA** will make no public announcement of working group meetings.

Issued in Washington, DC, on October 30, 2001.
Anthony F. Fazio,
Executive Director, Aviation Rulemaking Advisory Committee.
[FR Doc. 01-27998 Filed 11-6-01; 8:45 am]
BILLING CODE 4910-13-M

Recommendation Letter

Action ARM
AVR-1 S.

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

January 3, 2002

Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Attention: Mr. Nicholas Sabatini, Associate Administrator for Regulation and Certification AVR-1

Subject: ARAC Tasking Recommendation

Reference: FAA Tasking to ARAC, Federal Register, dated November 7, 2001, pages 56367 and 56368

Dear Mr. Sabatini,

The reference tasking to the Engine Harmonization Working Group of the Transport Airplane and Engine Issues Group asks ARAC to review the adequacy of existing bird ingestion standards for engines. The task also asks for recommendations in areas other than certification requirements where the potential exists to mitigate risks associated with bird ingestion.

With respect to the second part of the tasking, the TAEIG is pleased to forward to you the attached recommendations from the Engine Harmonization Working Group. Please note that these recommendations involve several branches within the FAA as well as other Departments within the Federal Government. The task group that developed these recommendations was chaired by Mr. Richard Parker of Pratt & Whitney. They have indicated their willingness to provide detailed briefings on the data that led to these recommendations should it be helpful in understanding and implementing them. Feel free to contact me if such a briefing would be helpful for the FAA or other governmental agencies.

Sincerely yours,

Craig R. Bolt

Craig R. Bolt
Assistant Chair, Transport Airplane and Engine Issues Group

Copies: Jerry McRoberts – RR
Richark Parker – P&W
Mike Kaszycki - FAA-NWR
Marc Bouthillier – FAA-NER
Effie Upshaw – FAA-ARM

Acknowledgement Letter

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

MAR 11 2002

Mr. Craig R. Bolt
Assistant Chair, Aviation Rulemaking
Advisory Committee
Pratt & Whitney
400 Main Street, Mail Stop 162-14
East Hartford, CT 06108

Dear Mr. Bolt:

Thank you for your January 3, 2002, letter transmitting recommendations on airport bird control measures. The letter is being forwarded to the Office of Airport Safety and Standards, Airport Safety and Operations Division (AAS-300), for evaluation and a response describing our next action. We plan to have that response to you by the end of May.

I wish to thank the Aviation Rulemaking Advisory Committee, particularly those members associated with the transport airplane and engine issues area and the Engine Harmonization Working Group for the resources that industry gave to develop the recommendations.

Sincerely,

Tony Fazio
Director, Office of Rulemaking

Recommendation

Bird Ingestion Phase II Task Group
Bird Management Recommendation

I - Recommendations

The Bird Ingestion Phase II Task Group, as tasked by ARAC, issues the following recommendations to address concerns regarding the hazard to commercial transport aircraft from large flocking birds.

Recommendation 1: ICAO and national regulators should establish regulations that require airports to develop and implement a bird control plan that includes control of the numbers of flocking bird species both on and adjacent to their property. National laws should be provided by the countries concerned to enable airports to carry out these activities.

Recommendation 2: National regulators should prevent the establishment of sites that are attractive to birds on, or in the vicinity of, airports.

Recommendation 3: Incentives need to be strengthened for airport operators and local authorities to take the necessary actions to reduce/eliminate hazardous wildlife and hazardous wildlife attractants on or near their airport.

Recommendation 4: Aviation safety regulators need to lead an effort to inform the public of the hazard to commercial air safety caused by wildlife.

Recommendation 5: Countries should establish mechanisms to review populations of flocking bird species over 4 lbs (1.8 kg) and then to manage populations in consultation with conservation and other interests to levels consistent with acceptable flight safety standards.

II - Summary

These recommendations are issued to address a potential hazard to commercial transport category aircraft. The vast majority of aircraft engines currently in service were designed and tested at a time when the populations of large flocking bird species were far lower than they are today. Engines were, therefore, not designed to withstand the ingestion of large birds such as the Snow Goose or the Canada Goose. Populations of these large birds have now increased to the point where they constitute an increasing hazard to these engines. Forecast continued population growth in many large bird species means that this hazard will increase further unless corrective action is taken.

Available data from transport aircraft engine ingestions to date shows that a significant number of the ingestions from encounters with large flocking birds occur outside the boundaries of airport control. This means that reducing the hazard from large flocking birds by control of birds on airport grounds only may not be sufficiently effective.

Following a Snow Goose flock encounter with a DC-9 aircraft, that resulted in loss of power from both of the aircraft's engines, and a recent B757 encounter with a flock of Starlings, the NTSB recognized the potential hazard to aviation posed by flocking birds and issued a series of 10 Safety Recommendations on November 19, 1999 to address the flocking bird hazard around airports. These recommendations included using existing technology and exploring future technologies that could be applied to protecting aircraft from bird ingestions in the vicinity of airports. The recommendations also included the statement:

> "...Various Federal agencies involved in aviation and wildlife protection have different missions and, sometimes, conflicting responsibilities and mandates. For example; the goals of improving aviation safety and promoting wildlife conservation through habitat protection, restoration, and enhancement sometimes conflict. The Safety Board concludes that the various agencies need to meet to consider a unified approach to the problem of bird strike hazards and to reconcile their different agendas. Therefore, the Safety Board believes that with representatives from the USDA, the Department of the Interior, the Department of Defense, and the U.S. Army Corps of Engineers, the FAA should convene a task force to establish a permanent bird strike working group to facilitate conflict

resolution and improve communication between aviation safety agencies and wildlife conservation interests..."

These words of the NTSB recommendation acknowledge the conflicting priorities of wildlife conservation measures to enhance bird populations and the requirement to balance conservation with other needs. It is the interpretation of the Bird Ingestion Phase II Task Group that these words provide for the consideration of controlling populations and the conclusion of this Task Group that reduction and control of populations of Canada geese and Snow geese should now be seriously considered.

The recommendations and the supporting discussion are primarily intended to address certain species of geese. However, it is not the intent to limit the scope of the recommendations to geese or other large birds. It should be recognized that any species of flocking bird can become a hazard if its populations are allowed to grow too large and/or movements around airports are allowed to any significant degree. Recent revisions to engine certification standards require new engines to better tolerate birds, such as gulls or smaller, and although this should reduce the hazard from smaller birds, it does not eliminate it.

III - Discussion

Current data indicate a rise in the population of the Snow goose and the Canada goose within the United States and other countries. The rise in population is reported to be exponential over the past 15 years. It is not clear when natural biological processes will begin to act to limit this population growth and sustain the population at a predictable level. Without any foreseeable natural elements limiting population growth, the best method currently available to predict future populations is to extend the historical growth rate mathematically.

This rise in the population of certain geese, along with the increase in commercial air transport traffic, represents a threat to air transportation because of the increased exposure that commercial aircraft will have to encounters with geese. The encounters become a potential hazard because geese fly in flocks. An encounter between an aircraft and a flock of these birds increases the possibility of multiple engine power loss plus other aircraft complications. In addition, there will likely be an increase in air traffic as public demand for air transportation is still expected to increase.

The industry projection is that aviation traffic will increase by approximately 40% within the next 10 years, despite recent events.

It has been shown by studies that the population of large flocking birds in the 1970-1980 time period was at a level that encounters with flocks were rare and the probability of multiple engine involvement was extremely remote. At the current goose population levels, the rate of aircraft encounters and potential for multiple engine involvement is no longer extremely remote. At the current rate of growth, the goose population will double every 5 to 7 years. With this forecast population growth, coupled with the projected increasing rate of aircraft traffic, the probability of multiple engine power loss and aircraft loss in the future will become unacceptable.

Efforts are being made to consider the feasibility of improving the tolerance of new aircraft engine designs to encounters with larger birds. Any tolerance improvements will not be timely in terms of affecting the projected hazard to air safety over the next 10 to 20 years as these improved products will enter service at a relatively slow rate. To revise certification standards, design new engines, design new aircraft, and get the new engines and aircraft into service in sufficient quantities for them to make a statistical difference will take more than 20 years. Also, there are approximately 14,000 transport category aircraft currently flying approximately 20,000,000 flights per year. These aircraft utilize engines that were designed as far back as the 1970's when the population of geese was at a level such that there was no significant measured threat from large flocking birds. The aircraft with these engines will continue to fly for the next 10-20 years.

For these reasons the Bird Ingestion Phase II Task Group recommends that the population of Snow Geese and resident Canada Geese around airports be reduced and their populations be controlled thereafter to levels that are consistent with an acceptable risk to aviation safety. This recommendation recognizes that there are current laws in the U.S. protecting migratory birds that initiated from conservation acts as early as 1917. It is the intent of this recommendation that conservation laws be updated to reflect the current status of large flocking bird populations, and that control of populations of certain birds be carried out, where necessary, in harmony with sensible conservation measures. This approach will insure that bird populations do not become excessive and a mutually protected environment is provided for the birds and the flying public.

13 November, 2001

Recommendation Letter

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U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Date: July 5, 2002

Version: 4 Version to be submitted to the ARAC TAEIG. Corresponds to JAA NPA-E-45 dated June 21, 2002.

File: AC3376-1Av4.doc

Subject: Bird Ingestion Certification Standards	**Date:** **Initiated By:** ANE-110	**AC No:** 33.76-1A **DRAFT** AC **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance and acceptable methods, but not the only methods, that may be used to demonstrate compliance with the bird ingestion requirements of § 33.76 of the Federal Regulations, Title 14 of the Code of Federal Regulations. Although this AC does refer to regulatory requirements that are mandatory, this AC is not, in itself, mandatory. This AC neither changes any regulatory requirements nor authorizes changes in or deviations from the regulatory requirements.

2. BACKGROUND.

a. This effort was adopted as a part 33 and Joint Aviation Regulations for engines (JAR-E) harmonization project and was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

b. This AC provides information and guidance that addresses Federal Aviation Administration (FAA) type certification standards for aircraft turbine engines with regard to bird ingestion. The requirements under § 33.76 reflect recent analysis of the bird threat encountered in service by turbine engine powered aircraft.

3. DEFINITIONS. For the purpose of this AC, the following definitions apply:

a. Ingestion. Ingestion is defined as the passage of a bird into the engine inlet and/or impact with engine structure.

b. Front of the Engine. The front of the engine is characterized as any part of the engine which can be struck by a bird. This includes, but is not limited to, the following:

(1) inlet mounted components,

(2) nose cone,

(3) spinner (centerbody) on the fan or compressor rotor,

(4) engine inlet guide vane assemblies,

(5) any engine protection device, and

(6) fan or compressor blades (including front and aft fan designs).

c. Minimum Engine. A minimum engine is defined as a new engine that exhibits the type design's most limiting operating parameter(s), with respect to the bird ingestion conditions prescribed in this AC. These operating parameters include, but are not limited to, power or thrust, turbine temperature, and rotor speed.

d. First Stage Rotating Blades. The term "first stage rotating blades" includes the first of the exposed stages of any fan or compressor rotor which are susceptible to a bird strike or bird ingestion. These first stage rotating blades are considered to be part of the front of the engine, as defined in paragraph (3)(b). This definition encompasses ducted, unducted and aft fan engine designs. In these latter cases, blading on multiple rotors (i.e., primary and secondary airflow paths) should be considered separately when complying with § 33.76.

e. Critical Impact Parameter (CIP). A parameter used to characterize the state of stress, strain, deflection, twist, or other condition which will result in the maximum impact damage to the engine for the prescribed bird ingestion condition.

f. Inlet Throat Area. The inlet throat area is the installation limitation on projected capture area of the engine inlet nacelle at its minimum inside diameter.

g. Airspeed for Normal Flight Operations. Normal flight operations with respect to airspeed refers to the range of airspeed values that is allowed under normal circumstances by existing air traffic control regulations.

4. GENERAL. The intent of § 33.76 is to require an applicant to demonstrate that the engine is designed and constructed to be structurally and operationally tolerant, to the degree specified, following the defined bird ingestion events.

a. Front of the Engine. The applicant should assess the bird impact to the critical parameters of the components at the front of the engine. For example, the ability of the spinner to withstand a bird impact should be assessed for the most critical parameters of the spinner. This assessment should include bird size, bird velocity, target location, and rotor speed.

b Artificial Birds. Artificial birds or devices which simulate the mass, shape, density, and impact effects of birds, and which are acceptable to the Administrator, may be used for the ingestion tests.

c. Critical Impact Parameter (CIP). The parameter is generally a function of such things as bird mass, bird velocity, fan/rotor speed, impact location, and fan/rotor blade geometry. The state of maximum impact damage to the engine is relative to the ability to meet the criteria of § 33.76. The CIP for most modern turbofan engines is fan blade leading edge stress, although other features or parameters may be more critical as a function of operating conditions or basic design. For turboprop and turbojet engines, a core feature will most likely be the critical consideration. Regardless of engine design, the most limiting parameter should be identified and understood prior to any demonstration, as any unplanned variations in controlling test parameters will be evaluated for the effect on the CIP and § 33.76 requirements.

(1) Example Considerations for Determining the CIP. For turbofan first stage fan blades, increasing the bird velocity or bird mass will increase the slice mass, and could shift the CIP from leading edge stress to blade root stress. For fan blades with part span shrouds, it may be blade deflection that produces shroud shingling and either thrust loss or a blade fracture that could be limiting. For unshrouded wide chord fan blades it may be the twist of the blade in the dovetail that allows it to impact the trailing blade resulting in trailing blade damage.

(2) CIP Tolerance. For certification tests, the CIP variation should not be greater than 10% as a function of any deviations in test plan controlling parameters.

d. Critical Test Parameters. In conducting the analysis or component tests, or both, to determine the critical ingestion parameters, the applicant should consider related experience for the type and size of engine being evaluated, with particular attention to the types and causes of failures in that related experience.

e. Engine Tests. Engine tests should be conducted with a fully operational engine representative of the type design. The normal functioning of any automatic protective or recovery systems not requiring pilot intervention is acceptable (including automatic power lever movement). However, any such automatic systems may be required for dispatch (e.g., Master Minimum Equipment List) if such functions are necessary to meet the requirements of § 33.76. The Applicant may also conduct the test(s) with any automatic systems in a functionally degraded state, if this does not constitute a less severe test.

f. Test Facilities. The test facility should be appropriately calibrated to ensure that the controlling parameters defined by the analysis of the critical conditions (e.g., bird speed, aiming locations) are within an acceptable tolerance. This tolerance band should be derived from an analysis of the sensitivity of the critical impact parameter to variations in the controlling parameters. The band should be such that variation in the most critical impact parameter is not more than 10% resulting from any combination of the controlling parameters (See paragraph 4. c. above). Also, certain test facilities and installations may affect or reduce the stability margin of the engine due to airflow distortion attributed to the close proximity bird gun(s) to the engine inlet. These effects must be identified prior to the test. Power or thrust should be measured by a means which can be shown to have an accuracy within plus or minus 3% of the specified levels.

g. Turboprop/Turboshaft Engine Tests. If turboprop or turboshaft engines are tested using an alternative load device which could induce different engine response characteristics compared to when the engine is coupled with a propeller or as installed in the aircraft, the interface with the test facility or other aircraft or propeller systems should be monitored during the test. These results should be used for determining how the engine would respond in a representative installation, and for ensuring that the engine would then comply with the requirements in § 33.76.

h. Aircraft/Engine Interface. The Installation Manual required under § 33.5 should describe the engine/aircraft interfaces which could be affected by bird ingestion events. Of particular interest would be dynamic interactions such as automatic surge recovery, auto relight, or propeller auto feather.

i. Inlet Throat Area. The Installation Manual required under § 33.5 should identify as an installation limitation the inlet throat area which was used to determine the quantity and weight of birds for the overall showing of compliance to § 33.76. Section 33.76(a)(2) contains the specific requirement for this installation limitation. The applicant should take care in determining this value with respect to future models or installations, which may require a larger number or size of birds or both. Note that the tables of bird quantities and weights within § 33.76 are based on inlet throat area, not the inlet highlight or engine front flange projected areas.

j. Derivative Engines and Major Design Changes. For type certification of derivative engine models or major design changes to existing models, the required engine tests should be performed under the conditions of § 33.76, unless representative demonstration evidence acceptable to the Administrator is provided. This substantiation evidence may come from the applicant's experience on engines of comparable size, design, construction, performance, and handling characteristics, obtained during previous certification testing, and may be supported by development or operational data. Any parametric analysis used as compliance substantiation for type certification or for major design change approval, should fall within a 10% or less variation in the most critical impact parameter(s) identified for the baseline engine certification. The critical impact parameter(s) is often associated with impact load at the point of bird and rotor blade contact. This is generally a function of bird speed, rotor speed, and blade twist angle. This 10% variation on the critical impact parameter should not be assumed to be a direct tolerance on the applicants proposed changes to takeoff power or thrust ratings themselves.

k. Fan Frame Struts and Bifurcation Strut Fairings: Main frame struts or bifurcation strut fairings may be exposed to bird debris impact from bird debris exiting the upstream fan rotor. Additionally, these frame struts or strut fairings may house fuel, oil, hydraulic, or high pressure bleed air lines, or wiring associated with the engine control system. The applicant should consider the potential for bird debris impact damage to these ducts such that sufficient strength exists to minimize damage to critical internal components in the event of impact to such structure.

SECTION 1
LARGE SINGLE BIRD INGESTION

5. GUIDANCE FOR LARGE SINGLE BIRD INGESTION.

a. For the purpose of the § 33.76 test, the complete loss of engine power or thrust after ingestion will be accepted.

b. The most critical location on the first stage rotating blades may be determined from analysis or component tests, or both. Determination of the most critical location to be considered should include evidence, where necessary, on:

(1) the effect of the bird strike on rotating components,

(2) the compressor casing strength,

(3) the possibility of multiple blade failures,

(4) the strength of the engine structure and main shafts relative to the unbalance and excessive torque likely to occur.

c. When compliance with the requirements of § 33.94(a) is used in place of the large bird ingestion engine test, the demonstration that the § 33.94(a) test constitutes a more severe demonstration of rotor blade containment, rotor unbalance, fire protection consideration and mount load capability, should consider the engine dynamic response to a large bird ingestion event, and include, but not be limited to:

(1) the effects of engine unbalance loads,

(2) engine torque loads,

(3) surge related loads, and

(4) axial loads, resulting from the bird impact which are transmitted to the engine structure.

(d) The 200 knots ingestion speed for the large bird requirement was selected as the optimum speed to accommodate, within a single demonstration, the various critical impact parameters (CIP) associated with typical turbofan engine designs currently in service. However, for a specific engine design, an ingestion speed other than 200 knots may be a more critical demonstration when considering the overall criteria of § 33.76(b). Therefore, if the applicant identifies and substantiates that a bird speed other than 200 knots is more conservative or more completely evaluates the proposed design, then the tests and analyses required under § 33.76(b) may be conducted at that ingestion speed, and should be noted in the certification basis as an equivalent level of safety finding under§ 21.21(6)(1).

(e) All components considered to be part of the front of the engine must be evaluated under 33.76(a)(3) and 33.76(b)(3)

SECTION 2
SMALL AND MEDIUM FLOCKING BIRD INGESTION

6. GUIDANCE FOR SMALL AND MEDIUM FLOCKING BIRD INGESTION.

a. The applicant should identify the critical target locations for the small and medium bird ingestion tests required by § 33.76(c), and consider potential effects of assumed installations in the aircraft. After targeting one bird for the most critical exposed location, the applicant should target any remaining birds in proportion to the fan face area, including the centerbody if applicable, to achieve an even distribution of birds over the face of the engine. The even distribution of remaining birds should also include consideration of any additional critical locations. Any critical locations not targeted may be evaluated separately by analysis or component testing, or both.

b. In the tests performed under § 33.76(c), the engine is required to produce at least 75% of takeoff power or thrust after ingestion of small and medium birds. A momentary power or thrust drop (e.g., surge recovery) below this value may be acceptable as long as the duration does not exceed 3 seconds.

c. The purpose of the sea level hot day corner point assessment under § 33.76(a)(1), is to address both the loss of margins to operating limitations (e.g., exhaust or measured gas temperature, rotor speeds, etc.), and also the influence of the engine control system limiters or controlling parameters on available power or thrust at the critical hot day corner point condition. This post test analysis approach allows testing at takeoff power or thrust for actual test day conditions, and provides a uniform assessment of power loss against rated levels independent of the actual tests ambient conditions. The assessment may be based on appropriate test, analysis, service events or combination thereof.

d. Rig tests may be used to determine if a particular bird size will pass through the inlet and into the rotor blades.

e. Thrust or power should be measured by a means which can be shown to be accurate throughout the test to enable the thrust or power to be set without undue delay andmaintained to within plus or minus 3% of the specified levels. If a sustained high vibration condition exists after the first 2 minutes of operation after the bird ingestion, then thrust or power may be varied as a protective measure within plus or minus 3% of the specified levels. Alternative load devices of some test facilities such as waterbrakes, may be unable to control power within the plus or minus 3% tolerance. This should be identified and approved prior to the test.

f. Exceedences of engine operating limits are not expected to occur. However, exceedences may be permitted to occur only during the first 2 minutes (reference § 33.76(c)(7)(ii)) following the ingestion of the birds in the 20 minute run-on test. Any limit exceedence(s) should be recorded, and it should be shown by evidence acceptable to the Administrator, that the limit exceedence(s) will not result in an unsafe condition (reference § 33.76(c)(10)). This evidence may come from previous test or service experience, or analysis thereof. Also, under such circumstances, the operating instructions, installation manual, and maintenance manual should be reviewed to assure that appropriate instructions are included within those documents, and that any such instructions are appropriately validated.

g. All components considered to be part of the front of the engine must be evaluated under 33.76(a)(3) and 33.76(c)(6).

SECTION 3
LARGE FLOCKING BIRD INGESTION

7. GUIDANCE FOR LARGE FLOCKING BIRD INGESTION

a. In accordance with Section 33.76(d)(2), engine power or thrust will be stabilized at a specific first stage rotor speed value (e.g., fan speed, N1, etc.) that is independent of test day ambient conditions or actual power or thrust produced at the time of the test. This rotor speed value corresponds to that which would produce 90% of maximum Rated Takeoff Power or Thrust when the engine is operated on an ISA standard day at sea level. The definition of first stage rotor can be found in Section 3(d) of this AC.

b. The applicant should select a target on the first exposed rotating stage or stages of the engine (e.g., fan) at a blade span airfoil height of 50% or further outboard as measured at the blade leading edge (see Figure 1). The specified target location is at the discretion of the applicant.. The use of ‘stage or stages’ is intended to allow for alternative designs such as rear mounted fans where each exposed stage will be evaluated independently.

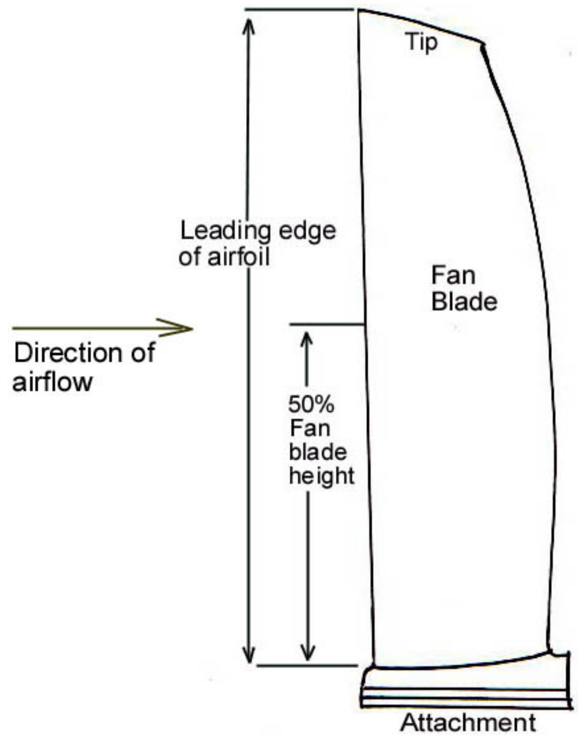

Figure 1. Location of target point on the leading edge of the fan blade. A typical fan blade is illustrated.

c. In the test performed under Section 33.76(d), the engine is required to run-on for a minimum of 20 minutes per the required run on schedule after ingestion of a large flocking bird (see Figure 2). A momentary power or thrust drop below this value may be acceptable as long as the duration does not exceed 3 seconds. Also, momentary power or thrust drops (e.g., surge recovery) below specified values when setting power during the run-on demonstration specified in 33.76(d)(5) may also be acceptable as long as the duration(s) does not exceed 3 seconds.

d. With respect to the run-on sequence specified in 33.76(d)(5):

1) Segment (5)(i) is 1 minute in duration, and no movement of the power lever is allowed. Any power or thrust equal to or greater than 50% of maximum rated takeoff is acceptable.

2) Segment (5)(ii) is 13 minutes in duration, and the thrust lever may be manipulated at the discretion of the applicant. During this portion of the test the applicant may set power or thrust where the engine can continue to operate for example to minimise exceedences and/or vibration, provided that no less than 50% power or thrust is maintained. It is also permissible for the applicant to vary the power control lever at any time and to any extent at any rate within this period of time provided that no less than 50% power or thrust is maintained.

3) The total time of the test may exceed 20 minutes due to the time used for accelerations and decelerations.

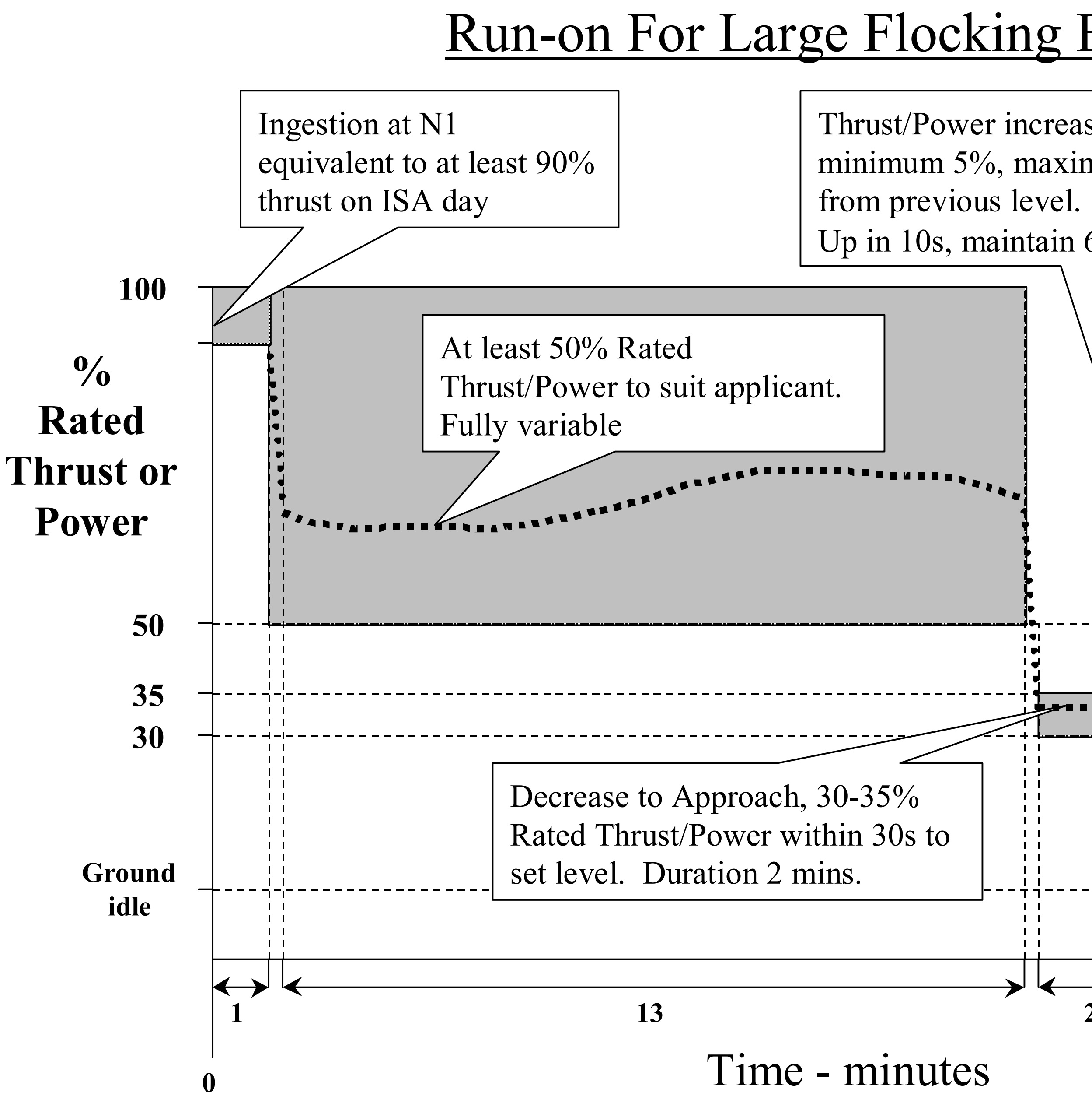

Figure 2. Run-on profile for large flocking bird test.

e. Any analytical means used to support compliance with the large flocking bird requirement under either 33.76(d)(6) method, should be validated by evidence based on representative tests and should have demonstrated its capability to predict engine test results.

f. A subassembly test under the 33.76(d)(6)(ii) method should include all type design hardware which are considered significant to the outcome of the test. Potential examples include, but are not limited to, fan blades and their retention/spacer components, fan inlet and outlet (exit) guide vanes; spinners, fan disks and shafts; fan cases; frames; main bearings and bearing supports including frangible bearing assemblies or devices; and other critical parts. The intent is that a subassembly test should adequately represent the mechanical aspects of a type design engine during large flocking bird ingestion. The dynamic effects (and related operability concerns) noted in this section include, but are not limited to, surge and stall, flameout, limit exceedences, and any other considerations relative to the type design engine's ability to comply with the requirements of 33.76(d)(4)/(5).

g. Engine operating limit exceedences may be permitted to occur during the 20 minute run-on. Any limit exceedence(s) should be recorded, and it should be shown by evidence acceptable to the Administrator, that the limit exceedence(s) will not result in an unsafe condition (reference section 33.76(d)(7)). This evidence may come from previous test or service experience, or analysis thereof. Also, under such circumstances, appropriate instructions should be included in the operating instructions, installation manual, and maintenance manual

SIGNATURE BLOCK

ARAC TAEIG EHWG BIRD INGESTION PHASE II

RECOMMENDATION FOR RULEMAKING (NPRM)

Date: July 12, 2002

Version: 5. Final EHWG product to be forwarded to TAIEG. Corresponds to JAA NPA-E-45 dated June 21, 2002.

File: nprm3376v5.doc

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No. XX]

Airworthiness Standards; Engine Bird Ingestion

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This document proposes to amend the FAA type certification standards for aircraft turbine engines with regard to bird ingestion capability. The proposed standards reflect recent analysis of the flocking bird threat encountered in service by turbine powered aircraft, and would harmonize the FAA bird ingestion standards with those being drafted by the Joint Aviation Authorities (JAA). The proposed changes would establish uniform bird ingestion standards for aircraft turbine engines certified by the United States under FAA standards and by the JAA countries under JAA standards, thereby simplifying airworthiness approvals for import and export.

DATE: Comments to be submitted on or before xx.

ADDRESSES:

FOR FURTHER INFORMATION CONTACT:

SUPPLEMENTARY INFORMATION:

-Comments Invited

-Availability of NPRM's

-Background:

<u>**Statement of Issue**</u>

The FAA recently adopted new regulations within part 33 to better address the overall bird ingestion threat in service. These requirements were adopted, in part, as a response to NTSB Recommendation A-76-64, which recommended an increase in the level of bird ingestion capability for aircraft engines. These requirements were adopted as Amendment 20 to part 33, Section 33.76, in September 2000.

As part of the dispositioning of NPRM comments for that rulemaking, the FAA agreed to a further study of the bird threat, and to evaluate the need for further rulemaking to address flocking birds larger than those addressed under the new Section 33.76. The actual comments to the NPRM in this regard stated that the threat from flocking birds with mass greater than 1.15 kg (2.5 lbs) was not covered by certification requirements, and that increasing populations of such large flocking birds could expand the threat posed by these size birds. The comments suggested that FAA should consider adoption of an additional requirement to address this portion of the demonstrated threat to assure that future engine products will continue to operate safely. In response to these comments, the FAA tasked the ARAC to review available bird ingestion data for flocking birds with mass larger than 1.15 kg (2.5 lbs), and to provide recommendations for rulemaking. The ARAC task was approved on May 24, 2001, and was assigned to the Engine Harmonization Working Group (EHWG) of the Transport Airplane and Engine Issues Group (TAEIG) on November 7, 2001. On [date] the TAEIG recommended that the FAA proceed with rulemaking to address the larger flocking bird threat with additional part 33 requirements. This NPRM reflects the ARAC recommendations for rulemaking in this regard.

Data Study

As part of this ARAC project, the FAA sponsored a contract with industry to collect and analyze pertinent bird ingestion data. This work is summarized in FAA Report No. TBD. The historical bird threat and resulting impact to flight safety for a 30-year period through 1999 has been reviewed as part of this effort. The data collected represents the worldwide non-military service experience of small, medium and large turbofan and turbojet engines in service during that time period, except for aircraft manufactured or flown in the former Soviet Union and Eastern European block countries. This includes, for two, three and four engined aircraft, over 325 million aircraft departures and approximately 340 events involving ingestions of large flocking birds (over 1.15kg [2.5 lbs. mass]).

Occurrences of loss of power on more than two engines are predicted to be extremely improbable based on the results of the data study. It was therefore concluded that the hazard to be addressed with this revision to the rule should be the dual engine power loss, from this point referred to as multi-engine power loss.

After collection and review of the available data, an analysis was performed to characterize the threat and consequences of bird ingestion. As a result of that analysis, the ARAC group identified flocking bird encounter threats more severe than specifically addressed under current 33.76. Note that throughout the study, birds were identified by species, and once identified an average mass for that species was typically assigned. All references to bird mass reflect the average mass for the species classification**.**

Data study observations for turbine engines with inlet throat areas greater than 3.9 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences involving birds greater than 1.15 kg (2.5 lb) have occurred; however, such events are currently predicted to occur at the rate of 1E-9 per aircraft flight hour based on the power-loss probabilities from smaller size engines. This is a conservative number since the expected power loss probability for this size engine is expected to be better than the smaller engines. There was insufficient data for this size engine to calculate the probability at this size.
2. There have not been any multi-engine ingestion events for bird classifications heavier than 1.15 kg (2.5 lb).

Data study observations for turbine engines with inlet throat areas between 3.5 and 3.9 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences involving birds greater than 1.15 kg (2.5 lb) have occurred, however such events are currently predicted to occur at the rate of approximately 1.1E-9 per aircraft flight hour.
2. Multi-engine ingestions of flocking birds greater than 1.15 kg. (2.5 lbs. mass) have occurred at a rate of 7.4E-8 per aircraft flight hour.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 3.65 kg (8 lbs.).

Data study observations for turbine engines with inlet areas between 2.5 and 3.5 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences have occurred with birds greater than 1.15 kg (2.5 lb.), however such events are currently predicted to occur at the rate of 1.5E-9 per aircraft flight hour.

2. Multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lbs.) have occurred at a rate of 3.2E-8 per aircraft flight hour.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 1.5 kg. (3.3 lbs.).

Data study observations for turbine engines with inlet areas between 1.35 and 2.5 m^2 are summarized as follows:

1. No multi-engine power loss events with Catastrophic aircraft consequences have occurred with birds greater than 1.15 kg (2.5lb.), however such events are currently predicted to occur at the rate of 2.8E-10 per aircraft flight hour.
2. No multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lb.) have occurred (one ground event did occur after landing).

Data study observations for turbine engines with inlet areas between 0.40 and 1.35 m^2 are summarized as follows:

1. One multi-engine power loss event involving a bird mass less than 1.15 kg (2.5 lbs.) with catastrophic aircraft consequences has occurred for large transport airplanes, and four for business jet applications.
2. Multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lbs.) have occurred at a rate of 2.5 per aircraft flight hour for large transport aircraft. Data for business jets were incomplete and therefore o rate was computed.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 3.65 kg. (8 lbs.).

Data study observations for turbine engines with an inlet area less than 0.40 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences with birds greater than 1.15 kg (2.5 lb.) have occurred in service. No multi-engine power loss events involving a bird mass less than 1.15 kg with catastrophic aircraft consequences have occurred involving transport category aircraft. Of the data provided on business jets, three multi-engine power loss events involving a bird mass less than 1.15 kg with catastrophic aircraft consequences have occurred.
2. Transport category aircraft multi-engine ingestions of flocking birds (of all mass sizes) have been reported to occur at a rate of 3.2E-8 per engine hour.
3. There have been no reported multi-engine ingestion events for bird classifications heavier than 1.15 kg (2.5 lbs. mass).

Based on the data review and analysis, the current requirements of 33.76, for all engine sizes, already support meeting the safety objective for medium birds, 1.15 kg and under.

It was concluded from the data study that already certified designs may be predicted to result in a hazardous condition at a probability that is slightly higher than the chosen safety objective. Therefore, a test with the average mass of the largest flocking bird to be considered (3.65 kg. / 8 lbs.) at critical conditions would significantly over achieve the safety objective defined below. As will be seen below, this conclusion has led to the acceptance of test parameters representative of in-service data.

Proposed Rule Safety Objective

Flocking birds may be ingested by more than one engine on the aircraft during one encounter. The safety objective of this proposed rule is to define certification criteria such that the predicted rate of catastrophic aircraft events from multiple engine power loss due to multi-engine ingestion of flocking birds weighing greater than 1.15 kg (2.5 lbs.) and up to 3.65 kg (8 lbs.) does not exceed 1E-9 events per aircraft flight hour. A catastrophic aircraft event might occur when damage to the engines results in an unsafe condition as specified in § 33.75; or where insufficient total aircraft power, thrust or engine operability is retained to provide adequate engine run-on capability to ensure continued safe flight and landing of the aircraft. It is not possible to demonstrate by a single test that any given engine design will experience no more than one multi-engine failure with catastrophic consequences to the aircraft due to ingestion of large flocking birds in 1E9 hours of fleet experience. However, it is possible to design a requirement which will provide the basis for predicting that level of reliability on a fleet wide basis. This statement is based on the following assumptions:

1) Current bird control standards for airport certification will be maintained.
2) Airport operators, air traffic controllers, and pilots will maintain their current awareness of the bird ingestion threat.
3) Any increase in the large flocking bird multi-engine ingestion rate over the next ten years will not exceed values estimated from the current bird growth rate observed in the data study.

The safety objective for this proposed rule has been applied at the world fleet level. The world fleet of turbine powered airplanes is comprised of two, three, and four engine airplanes. The large engine historical fleet experience of multiple engine ingestions is dominated by three and four engine airplane data, however two engine airplanes are likely to dominate the future fleet. This evolving situation was considered within this rulemaking effort, with assumptions about future fleet makeup playing a role in the selection of the new requirements.

With respect to bird ingestion, differences between these aircraft types generally relate to either dual engine bird ingestion rate, or probability of hazardous consequence given an actual dual engine power loss. For example, twin engine airplanes will have a higher probability of hazardous consequence given an actual dual engine power loss; however their dual engine bird ingestion rate (and resulting power loss) is much lower than that of the three and four engine airplanes. On the other hand, three and four engine airplanes while having substantially higher rates of dual engine bird ingestion (and resulting powerloss), are less likely to suffer a hazardous consequence should a dual engine powerloss actually occur.

A review of world fleet service data indicates that the higher rate of dual engine bird ingestion occurrences for three and four engine airplanes determines the rate for the entire fleet of large engines. This rulemaking is based on the current world fleet distribution of two, three, and four engine airplanes in determining the new requirements necessary to meet the safety objective. Therefore, since the world fleet of large engines is becoming increasingly populated with two engine airplanes, this new rule will become more conservative and provide an even higher level of safety with respect to the dual engine bird ingestion threat to airplanes in service for these size engines. For small and medium size engines, the world fleet is overwhelmingly made up of twin engine airplanes. This situation is not likely to change over time. Therefore the multi-engine ingestion rate data reflects the current fleet makeup.

Proposed Rule Parameter Selection

To establish the test conditions that would satisfy the safety objective, it was determined that a probabilistic analysis would be necessary. The probability of a dual engine power loss given a dual engine ingestion involves considerations of dependent and independent conditions. There is dependence in that during a flock encounter, both engines are traveling at the same forward speed (that of the aircraft) and will be at the same power setting. The independent conditions involve the specifics of the actual impact of the bird with the engine. Because of the combination of dependent and independent conditions involved in the analysis, simple numeric relationships for determining dual engine power loss probabilities would not be appropriate. Therefore a Monte Carlo simulation was selected as the best tool to use for this probabilistic analysis. The selection of appropriate values for the analysis and a description of the analysis techniques are given below.

This proposal recognizes the need to design a test that is representative of in-service combinations of critical ingestion parameters. Therefore, engine ingestion parameters for actual events resulting in sustained power loss were evaluated. The most critical parameters that affect power loss have been found to be bird mass, bird velocity, impact location, and engine power setting. Since testing for all possible combinations of parameters is impractical, it has been necessary to derive a single certification test demonstration that will support meeting the safety objective. Definition of this test demonstration has been accomplished by using a Monte Carlo statistical analysis to show that the demonstration covers a sufficient percentage of possible critical parameter combinations so as to support meeting the safety objective for birds in the 1.15 kg. (2.5 lbs.) to 3.65 kg. (8lbs.) mass range.

The data study was used to determine the probability of a catastrophic consequence to an aircraft in order to define a test that would be likely to achieve the aircraft level fleet safety objective. The single engine ingestion rate and multiple engine ingestion (MEI) rates for birds with mass greater than 1.15 kg. (2.5 lbs.) were taken from the data, along with the fleet average flight length of 3.2 hours for large engine installations, and 1.7 hours for small and medium engine installations. From historical accident/incident service data, an aircraft Hazard Ratio (HR; the number of aircraft accidents divided by the number of dual engine power losses was determined as described below. A dual engine powerloss is an event where at least two engines on an aircraft have a combined thrust loss greater than the maximum thrust of one engine. The MEI rate, average flight length and HR were analyzed to establish test parameters and conditions that would be consistent with the safety objective.

Hazard Ratio:

To establish the Hazard Ratio, a list containing multiple engine power loss events was provided by the FAA. This list included the following

1) FAA data showing a hazard ratio for twin engine aircraft alone at 0.33 and all aircraft events at 0.07;

2) The AIA Propulsion Committee report (PC342, in support of CAAM) which documented a hazard ratio of 0.07.

3) Boeing supplied data of large high bypass ratio engines documenting a hazard ratio of 0.05.

A hazard ratio of 0.18 was selected for all engines. This hazard ratio was accepted as being appropriate for the specific data set being utilized. Statistical confidence bands of 75% and 90% on each data category were tabulated for comparison and yielded a similar result, giving confidence in the value selected. For consistency with this single hazard ratio, a standard mix of 75% twins and 25% quads (based on aircraft flights) was applied to all engine size classes.

Monte Carlo Analysis:

Several simulations were run to establish the single engine failure probability, given a large flocking bird ingestion that would produce a dual engine power loss probability within the safety objective. An arithmetic calculation working backwards from the safety objective then established a multiple engine power loss rate that would satisfy the safety objective. The simulations involved inputting bird strike impact energy into the first stage rotor in accordance with variations of the above input parameters determined by service data probability curves. Initial simulations defined a parameter boundary created by the current and proposed certification requirements (independent of fan blade design) that would meet the safety objective. Other simulations input structural features from current in-service fan blades that have demonstrated acceptable bird ingestion capability; or input structural characteristic maps of new design fan blades.

The Monte Carlo simulation used as random inputs:

1) takeoff or approach phase ingestion probabilities established from the data study. The data study showed a 50/50 split between takeoff and approach encounters,
2) engine takeoff first stage rotor speed based on actual service data,
3) impact on the engine fan face based on area,
4) aircraft forward speed based on actual service data.
5) the bird size based on a probability distribution established from the data study for birds greater than 1.15 kg. (2.5 lbs.) but less than or equal to 3.65 kg. (8 lbs.).

The Monte Carlo simulation also accounted for installation effects at the fan blade tip (tip shielding). An installed engine has the proximity of the nacelle structure, particularly the inlet cowl that reduces the exposure of the fan blade tip to direct impact by large birds. The reduction in exposed diameter is close to 10% but varies slightly with engine diameter.

The engine structure considered consists of any inlet structure that can be impacted by an ingested bird, to include but not be limited to inlet guide vanes, spinners, and fairings. Static engine inlet structure that would be certified as part of the engine, and which could be impacted by a bird prior to the bird impacting the first rotating stage of an engine compressor was also evaluated in the analysis. Of particular interest was the fan fairing (e.g., spinner or bullet nose), that directs inlet air around the fan hub into the core or fan bypass airflows. With current technology, this fairing is approximately one third of the diameter of the fan, which is approximately 11% of the fan area. The data shows that this fairing is impacted in service by birds in proportion to its area. The data also shows that fairings certified with engines to the requirements of FAR 33.77 Amendment 6 have not caused an engine power loss from impacts due to birds of any size, including large flocking birds. The current requirement of FAR 33.76 requires that the fairing demonstrate capability for 1.15 kg. (2.5 lbs.) birds at the critical location at 250 knots impact velocity. The requirements for the fairing, with conservative allowance for the size of the critical area of the fairing, were input into the Monte Carlo analysis. The Monte Carlo analysis included impacts to the fairing as well as the fan blades for the overall evaluation. The Monte Carlo analysis results showed that the safety target could be met for inlet components meeting the current requirements of 33.76. It was therefore accepted that the current requirements of FAR 33.76 provide adequate standards, and that no additional rule making is required for these classes of components. However it was decided to revise the Advisory Circular to clarify and stress what the current requirements and acceptable methods of compliance are for inlet components.

The various methods of Monte Carlo simulation were in general agreement, thereby providing an independent cross-check that the proposed rule requirements can support achieving the safety objective.

Test Conditions:

The following test conditions have been established from the above**:**

Power/Thrust & Rotor Speeds: The first stage of rotating blades of the engine is the feature of a typical turbine engine most susceptible to damage from large flocking birds, and which can result in loss of engine power. It was shown that selecting a first stage rotor rotational speed that most engines were likely to be at during takeoff would support meeting the safety objective. Analysis of manufacturer collected service data, which includes de-rated thrust operations for the world fleet, showed that this first stage rotor speed, on a fleet average basis, corresponds to 90% of maximum rated takeoff power or thrust on an ISA standard day. It was therefore established that the thrust or power setting for the test demonstration would be based on first stage rotor speed itself, which will be equal to a rotor speed that corresponds to engine operation at 90% of maximum rated takeoff power or thrust on an ISA standard day.

Bird Velocity: The velocity of the bird during the test represents the velocity of the aircraft at the time of ingestion. Ingestions that occur at speeds lower than flight speeds result in rejected takeoffs and therefore are a lesser hazard to the aircraft. Flight speeds at altitudes where large flocking birds are most encountered range between 150 and 250 knots. Damage to an engine due to a bird ingestion results from a combination of parameters that include ingestion speed, first stage rotor speed and location of impact on the rotor blade span. For many designs, analysis showed that a bird speed less than 250 knots is generally more conservative. The data shows that the most representative aircraft speed for encounters with large flocking birds is approximately 200 knots and it was therefore established that this would be the impact speed for the test demonstration.

Target Location: The Monte Carlo simulations have shown that a test with bird impact at 50% fan blade height or greater will support attainment of the required safety objective in conjunction with the other test parameters described above. This aspect of the overall analysis assumes that the first stage blades will be more capable inboard of the 50% location than outboard, and that core ingestion capability is adequately addressed under the medium bird requirements.

Run-on: The purposes of the run-on demonstration are to show that the engine is capable of providing sufficient power, thrust and operability after the ingestion to continue a take-off, initial climb, and perform one air turnback, with a safe return for landing. It was considered that current procedures recommended by the aircraft manufacturers and the regulators, following an engine malfunction, is for flight crews to concentrate on flying the aircraft without throttle manipulation, regardless of the nature of an engine malfunction, until an altitude of at least 400 ft is reached. It was considered that ingestion of large flocking birds could damage the engines such that maneuvering the aircraft to a safe landing would be executed at high priority. Also it was considered that the aircraft would have to be flown in a manner such that flight crews could maintain the aircraft on glide slope. The run on time for the large flocking bird ingestion test has therefore been set at a minimum of 20 minutes (as for the medium bird test), with the initial minute after ingestion with no throttle manipulation where the engine must produce more than 50% maximum rated thrust, thirteen minutes where the engine is to maintain no less than 50% maximum rated thrust, but the throttle may be manipulated, to provide opportunity for the aircraft to establish itself in a return approach attitude, then a 5 minute period at approach thrust with a one minute thrust bump to demonstrate that a flight crew could establish approach thrust and manipulate the throttle sufficient to maintain glide slope during approach and landing. There is a final minute where the engine is to demonstrate that it can be brought safely to ground idle and shutdown.

Bird Mass/Weight: For engines with inlet throat area greater than 3.9 m2 (6045 sq. in.), a bird size of 2.5 kg. (5.5 lbs.) is representative of the average Snow Goose, one of the species identified as a key large flocking bird threat. The analysis shows that a 2.5 kg. (5.5lbs.) bird for the certification requirement, tested at the conditions specified, provides mitigation of the risk for bird masses greater than 1.15 kg. (2.5 lbs.) and up to 3.65kg (8lb) at the current and projected threat based on dual engine ingestion rates. The demonstration using a 2.5 kg. (5.5 lbs.) bird at the conditions specified, establishes the capability level of the blade at a location on the blade that represents a minimum of half of the exposed area of the first stage rotating blades. The probabilistic assessment using the Monte Carlo as described using the demonstrated capability level showed that the safety objective was met.

For engines with an inlet throat area between 3.5-3.9 m2 (5425-6045 sq. in.), it was determined that a large flocking bird demonstration with a 2.1 kg (4.63 lbs.) bird would be required to meet the safety goal.

For engines with an inlet throat area between 2.5-3.5 m2 (3875-5425 sq. in.), it was determined that a large flocking bird demonstration with a 1.85 kg (4.08 lbs.) bird would be required to meet the safety goal.

For engines with an inlet throat area of 2.5 m2 (3875 sq. in.) or less, the data review and analysis showed that the current requirements of 33.76 (for these size engines) already supports meeting the safety objective proposed for this rulemaking. Therefore, the current requirements of 33.76 for engines with inlet throat areas of 2.5m2 (3875 in2) or less will remain unchanged.

<u>Conclusion</u>

The task group concluded that the proposed rule would support achieving the target level of safety against the currently identified large flocking bird threat.

It should be noted that the EHWG has also issued recommendations on the need to control Snow and Canada geese populations and their movements near airports. The ARAC TAEIG received these recommendations on December 4, 2001 (EHWG letter dated November 13, 2001). These strengthened requirements for the certification of the engines may not be adequate to attain the safety goal if the numbers of these birds or their movements significantly increases compared to the present situation.

This proposed regulation may have safety significance with respect to the requirements of Section 21.101, Designation of Applicable Regulations for Changes to Type Certificates.

General Discussion of the Proposals

<u>Section 33.76</u>

The proposed revision to § 33.76 would add a new requirement for larger flocking birds to the existing regulation. This proposal was developed by the EHWG, and contains substantial common language between part 33 and JAR-E.

Paperwork Reduction Act

As there are no requirements for information collection associated with this proposed rule, no analysis of paperwork requirements is required under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.).

Regulatory Evaluation Summary

Four principal requirements pertain to the economic impacts of changes to the Federal regulations. First, Executive Order 12866 directs Federal agencies to promulgate new regulations or modify existing regulations after consideration of the expected benefits to society and the expected costs. The order also requires federal agencies to assess whether a proposed rule is considered a “significant regulatory action.” Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effect of regulatory changes on international trade. Finally, Public Law 104-4 requires federal agencies to assess the impact of any federal mandates on state, local, tribal governments, and the private sector.

In conducting these analyses, the FAA has determined that this proposed rule would generate cost-savings that would exceed any costs, and is not “significant” as defined under section 3 (f) of Executive Order 12866 and DOT policies and procedures (44 FR 11034, February 26, 1979). In addition, under the Regulatory Flexibility Determination, the FAA certifies that this proposal would not have a significant impact on a substantial number of small entities. Furthermore, this proposal would not impose restraints on international trade. Finally, the FAA has determined that the proposal would not impose a federal mandate on state, local, or tribal governments, or the private sector of $100 million per year. These analyses, available in the docket, are summarized below.

Cost and Benefits

International Trade Impact Analysis

The proposed rule would have little or no affect on international trade for either U.S. firms marketing turbine engines in foreign markets or foreign firms marketing turbine engines in the U.S.

Regulatory Flexibility Determination

~~*The Regulatory Flexibility Act of 1980 establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations,*~~

~~*and governmental jurisdictions subject to regulation." To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.*~~

Agencies must perform a preliminary analysis of all proposed rules to determine whether the rule will have a significant economic impact on a substantial number of small entities; if the determination is that it will, the agency must prepare an initial regulatory flexibility analysis (RFA).

However, if after a preliminary analysis for a proposed or final rule, an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, Section 605(b) of the Act provides that the head of the agency may so certify. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA conducted the required preliminary analysis of this proposal and determined...

Federalism Implications

The regulations proposed herein would not have substantial direct affects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government; and would not impose substantial direct compliance costs on States or local governments. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient federalism implications to require consultation with representatives of affected States and local governments.

In addition, the regulations proposed herein would not significantly or uniquely affect the communities of the Indian tribal governments and would not impose substantial direct compliance costs on such communities. Therefore, in accordance with Executive Order 13084, it is determined that this proposal would not require consultation with representatives of affected Indian tribal governments.

Environmental Assessment

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment (EA) or environmental impact statement (EIS). In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), regulations, standards, and exemptions (excluding those, which if implemented may cause a significant impact on the human environment) qualify for a categorical exclusion. The FAA has determined that this rule qualifies for a categorical exclusion because no significant impacts to the environment are expected to result from its finalization or implementation. In accordance with FAA Order 1050.1D, paragraph 32, the FAA has determined that there are no extraordinary circumstances warranting preparation of an environmental assessment for this proposed rule.

List of Subjects in 14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 33 of Title 14, Code of Federal Regulations as follows:

PART 33 - AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

1. The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

2. Section 33.76 is revised to read as follows:

33.76 BIRD INGESTION

(a) *General.* Compliance with paragraphs (b), (c), and (d) of this section shall be in accordance with the following:

(1) Except as specified in paragraph (d) of this section, all ingestion tests shall...***
(2) ***
(3) The impact to...conditions prescribed in paragraphs (b), (c) or (d) of this section... cannot comply with the requirements of paragraphs (b)(3) and (c)(6) and (d)(4) of this section.
(4) ***
(5) Objects that …. paragraphs (b), (c) and (d) of this section.
(6) ***

(b) *Large single birds*. Compliance with...***

(c) *Small and medium flocking birds.* Compliance with...***

(d) *Large flocking bird.* An engine test will be carried out at the conditions specified below:

(1) Large flocking bird engine tests will be conducted using the bird mass/weights in Table 4, and ingested at a bird velocity of 200 knots.

(2) Prior to the ingestion, the engine must be stabilized at no less than the mechanical rotor speed of the first exposed stage or stages that, on an ISA standard day, would produce 90% of the sea level static Maximum Rated Takeoff Power or Thrust.

(3) The bird must be targeted on the first exposed rotating stage or stages at a blade airfoil height of not less than 50% measured at the leading edge.

(4) Ingestion of a large flocking bird under the conditions prescribed in this paragraph must not cause any of the following:

i) A sustained reduction of power or thrust to less than 50% Maximum Rated Takeoff Power or Thrust during the run-on segment specified under Section (5)(i).

(ii) The engine to be shutdown during the required run-on demonstration prescribed in paragraph (5) of this section.

(iii) The conditions defined in paragraph 33.76(b)(3) of this section.

(5) The following test schedule shall be used:

(i) Ingestion followed by 1 minute without power lever movement.

(ii) Followed by 13 minutes at not less than 50% of Maximum Rated Takeoff Power or Thrust.

(iii) Followed by 2 minutes between 30 and 35% of Maximum Rated Takeoff Power or Thrust.

(iv) Followed by 1 minute with power or thrust increased from that set in (5)(iii) by between 5% and 10% of Maximum Rated Takeoff Power or Thrust.

(v) Followed by 2 minutes with power or thrust reduced from that set in (5)(iv) by between 5% and 10% of Maximum Rated Takeoff Power or Thrust.

(vi) Followed by a minimum of 1 minute at ground idle then engine shutdown.

The durations specified are times at the defined conditions. Power lever movement between each condition will be 10 seconds or less, except that power lever movements allowed within (5)(ii) are not limited, and for setting power under (5)(iii) will be 30 seconds or less.

(6) Compliance with the large flocking bird ingestion requirements of this paragraph may also be shown by:

(i) Incorporating the requirements of 33.76(d)(4)/(5) into the single large bird test demonstration specified in section 33.76(b)(1); or,

(ii) Use of an engine subassembly test at the ingestion conditions specified in section 33.76(b)(1) if:

1. All components critical to complying with the requirements of 33.76(d) are included in the subassembly test; and

2. The components of (1) are installed in a representative engine for a run-on demonstration in accordance with 33.76(d)(4)/(5); except 33.76(d)(5),(i) is deleted and (ii) must be 14 minutes in duration after the engine is started and stabilized and

3. Dynamic effects that would have been experienced during a full engine ingestion test can be shown to be negligible with respect to meeting the requirements of 33.76(d)(4)/(5).

(7) If any engine operating limit(s) is exceeded during the run on period then it shall be established that the limit exceedence(s) will not result in an unsafe condition.

Table 4 to Section 33.76 – Large Flocking Bird Mass/Weight

Engine Inlet Throat Area m2(in2)	**Bird Quantity**	**Bird Mass/Weight kg.(lbs.)**

A < 2.50 (3875)	**None**	**--**
2.50 < A < 3.50 (5425)	**1**	**1.85 kg (4.08 lbs.)**
3.50 ≤ A < 3.90 (6045)	**1**	2.10 (4.63lbs.)
3.90 (6045) ≤ A	**1**	**2.50 (5.51 lbs.)**

Issued in Washington, DC, on

Director, Aircraft Certification Service.

Acknowledgement Letter

TAE
Eng. H. WG
#19

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

MAR 11 2002

Mr. Craig R. Bolt
Assistant Chair, Aviation Rulemaking
Advisory Committee
Pratt & Whitney
400 Main Street, Mail Stop 162-14
East Hartford, CT 06108

Dear Mr. Bolt:

Thank you for your January 3, 2002, letter transmitting recommendations on airport bird control measures. The letter is being forwarded to the Office of Airport Safety and Standards, Airport Safety and Operations Division (AAS-300), for evaluation and a response describing our next action. We plan to have that response to you by the end of May.

I wish to thank the Aviation Rulemaking Advisory Committee, particularly those members associated with the transport airplane and engine issues area and the Engine Harmonization Working Group for the resources that industry gave to develop the recommendations.

Sincerely,

Tony Fazio
Director, Office of Rulemaking

Recommendation

Table of Contents

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Date: July 5, 2002

Version: 4 Version to be submitted to the ARAC TAEIG. Corresponds to JAA NPA-E-45 dated June 21, 2002.

File: AC3376-1Av4.doc

Subject: Bird Ingestion Certification Standards

Date:
Initiated By: ANE-110

AC No: 33.76-1A **DRAFT**
AC **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance and acceptable methods, but not the only methods, that may be used to demonstrate compliance with the bird ingestion requirements of § 33.76 of the Federal Regulations, Title 14 of the Code of Federal Regulations. Although this AC does refer to regulatory requirements that are mandatory, this AC is not, in itself, mandatory. This AC neither changes any regulatory requirements nor authorizes changes in or deviations from the regulatory requirements.

2. BACKGROUND.

a. This effort was adopted as a part 33 and Joint Aviation Regulations for engines (JAR-E) harmonization project and was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

b. This AC provides information and guidance that addresses Federal Aviation Administration (FAA) type certification standards for aircraft turbine engines with regard to bird ingestion. The requirements under § 33.76 reflect recent analysis of the bird threat encountered in service by turbine engine powered aircraft.

3. DEFINITIONS. For the purpose of this AC, the following definitions apply:

a. Ingestion. Ingestion is defined as the passage of a bird into the engine inlet and/or impact with engine structure.

b. Front of the Engine. The front of the engine is characterized as any part of the engine which can be struck by a bird. This includes, but is not limited to, the following:

(1) inlet mounted components,

(2) nose cone,

(3) spinner (centerbody) on the fan or compressor rotor,

(4) engine inlet guide vane assemblies,

(5) any engine protection device, and

(6) fan or compressor blades (including front and aft fan designs).

c. Minimum Engine. A minimum engine is defined as a new engine that exhibits the type design's most limiting operating parameter(s), with respect to the bird ingestion conditions prescribed in this AC. These operating parameters include, but are not limited to, power or thrust, turbine temperature, and rotor speed.

d. First Stage Rotating Blades. The term "first stage rotating blades" includes the first of the exposed stages of any fan or compressor rotor which are susceptible to a bird strike or bird ingestion. These first stage rotating blades are considered to be part of the front of the engine, as defined in paragraph (3)(b). This definition encompasses ducted, unducted and aft fan engine designs. In these latter cases, blading on multiple rotors (i.e., primary and secondary airflow paths) should be considered separately when complying with § 33.76.

e. Critical Impact Parameter (CIP). A parameter used to characterize the state of stress, strain, deflection, twist, or other condition which will result in the maximum impact damage to the engine for the prescribed bird ingestion condition.

f. Inlet Throat Area. The inlet throat area is the installation limitation on projected capture area of the engine inlet nacelle at its minimum inside diameter.

g. Airspeed for Normal Flight Operations. Normal flight operations with respect to airspeed refers to the range of airspeed values that is allowed under normal circumstances by existing air traffic control regulations.

4. GENERAL. The intent of § 33.76 is to require an applicant to demonstrate that the engine is designed and constructed to be structurally and operationally tolerant, to the degree specified, following the defined bird ingestion events.

a. Front of the Engine. The applicant should assess the bird impact to the critical parameters of the components at the front of the engine. For example, the ability of the spinner to withstand a bird impact should be assessed for the most critical parameters of the spinner. This assessment should include bird size, bird velocity, target location, and rotor speed.

b Artificial Birds. Artificial birds or devices which simulate the mass, shape, density, and impact effects of birds, and which are acceptable to the Administrator, may be used for the ingestion tests.

c. Critical Impact Parameter (CIP). The parameter is generally a function of such things as bird mass, bird velocity, fan/rotor speed, impact location, and fan/rotor blade geometry. The state of maximum impact damage to the engine is relative to the ability to meet the criteria of § 33.76. The CIP for most modern turbofan engines is fan blade leading edge stress, although other features or parameters may be more critical as a function of operating conditions or basic design. For turboprop and turbojet engines, a core feature will most likely be the critical consideration. Regardless of engine design, the most limiting parameter should be identified and understood prior to any demonstration, as any unplanned variations in controlling test parameters will be evaluated for the effect on the CIP and § 33.76 requirements.

(1) Example Considerations for Determining the CIP. For turbofan first stage fan blades, increasing the bird velocity or bird mass will increase the slice mass, and could shift the CIP from leading edge stress to blade root stress. For fan blades with part span shrouds, it may be blade deflection that produces shroud shingling and either thrust loss or a blade fracture that could be limiting. For unshrouded wide chord fan blades it may be the twist of the blade in the dovetail that allows it to impact the trailing blade resulting in trailing blade damage.

(2) CIP Tolerance. For certification tests, the CIP variation should not be greater than 10% as a function of any deviations in test plan controlling parameters.

d. Critical Test Parameters. In conducting the analysis or component tests, or both, to determine the critical ingestion parameters, the applicant should consider related experience for the type and size of engine being evaluated, with particular attention to the types and causes of failures in that related experience.

e. Engine Tests. Engine tests should be conducted with a fully operational engine representative of the type design. The normal functioning of any automatic protective or recovery systems not requiring pilot intervention is acceptable (including automatic power lever movement). However, any such automatic systems may be required for dispatch (e.g., Master Minimum Equipment List) if such functions are necessary to meet the requirements of § 33.76. The Applicant may also conduct the test(s) with any automatic systems in a functionally degraded state, if this does not constitute a less severe test.

f. Test Facilities. The test facility should be appropriately calibrated to ensure that the controlling parameters defined by the analysis of the critical conditions (e.g., bird speed, aiming locations) are within an acceptable tolerance. This tolerance band should be derived from an analysis of the sensitivity of the critical impact parameter to variations in the controlling parameters. The band should be such that variation in the most critical impact parameter is not more than 10% resulting from any combination of the controlling parameters (See paragraph 4. c. above). Also, certain test facilities and installations may affect or reduce the stability margin of the engine due to airflow distortion attributed to the close proximity bird gun(s) to the engine inlet. These effects must be identified prior to the test. Power or thrust should be measured by a means which can be shown to have an accuracy within plus or minus 3% of the specified levels.

g. Turboprop/Turboshaft Engine Tests. If turboprop or turboshaft engines are tested using an alternative load device which could induce different engine response characteristics compared to when the engine is coupled with a propeller or as installed in the aircraft, the interface with the test facility or other aircraft or propeller systems should be monitored during the test. These results should be used for determining how the engine would respond in a representative installation, and for ensuring that the engine would then comply with the requirements in § 33.76.

h. Aircraft/Engine Interface. The Installation Manual required under § 33.5 should describe the engine/aircraft interfaces which could be affected by bird ingestion events. Of particular interest would be dynamic interactions such as automatic surge recovery, auto relight, or propeller auto feather.

i. Inlet Throat Area. The Installation Manual required under § 33.5 should identify as an installation limitation the inlet throat area which was used to determine the quantity and weight of birds for the overall showing of compliance to § 33.76. Section 33.76(a)(2) contains the specific requirement for this installation limitation. The applicant should take care in determining this value with respect to future models or installations, which may require a larger number or size of birds or both. Note that the tables of bird quantities and weights within § 33.76 are based on inlet throat area, not the inlet highlight or engine front flange projected areas.

j. Derivative Engines and Major Design Changes. For type certification of derivative engine models or major design changes to existing models, the required engine tests should be performed under the conditions of § 33.76, unless representative demonstration evidence acceptable to the Administrator is provided. This substantiation evidence may come from the applicant's experience on engines of comparable size, design, construction, performance, and handling characteristics, obtained during previous certification testing, and may be supported by development or operational data. Any parametric analysis used as compliance substantiation for type certification or for major design change approval, should fall within a 10% or less variation in the most critical impact parameter(s) identified for the baseline engine certification. The critical impact parameter(s) is often associated with impact load at the point of bird and rotor blade contact. This is generally a function of bird speed, rotor speed, and blade twist angle. This 10% variation on the critical impact parameter should not be assumed to be a direct tolerance on the applicants proposed changes to takeoff power or thrust ratings themselves.

k. Fan Frame Struts and Bifurcation Strut Fairings: Main frame struts or bifurcation strut fairings may be exposed to bird debris impact from bird debris exiting the upstream fan rotor. Additionally, these frame struts or strut fairings may house fuel, oil, hydraulic, or high pressure bleed air lines, or wiring associated with the engine control system. The applicant should consider the potential for bird debris impact damage to these ducts such that sufficient strength exists to minimize damage to critical internal components in the event of impact to such structure.

SECTION 1
LARGE SINGLE BIRD INGESTION

5. GUIDANCE FOR LARGE SINGLE BIRD INGESTION.

a. For the purpose of the § 33.76 test, the complete loss of engine power or thrust after ingestion will be accepted.

b. The most critical location on the first stage rotating blades may be determined from analysis or component tests, or both. Determination of the most critical location to be considered should include evidence, where necessary, on:

(1) the effect of the bird strike on rotating components,

(2) the compressor casing strength,

(3) the possibility of multiple blade failures,

(4) the strength of the engine structure and main shafts relative to the unbalance and excessive torque likely to occur.

c. When compliance with the requirements of § 33.94(a) is used in place of the large bird ingestion engine test, the demonstration that the § 33.94(a) test constitutes a more severe demonstration of rotor blade containment, rotor unbalance, fire protection consideration and mount load capability, should consider the engine dynamic response to a large bird ingestion event, and include, but not be limited to:

(1) the effects of engine unbalance loads,

(2) engine torque loads,

(3) surge related loads, and

(4) axial loads, resulting from the bird impact which are transmitted to the engine structure.

(d) The 200 knots ingestion speed for the large bird requirement was selected as the optimum speed to accommodate, within a single demonstration, the various critical impact parameters (CIP) associated with typical turbofan engine designs currently in service. However, for a specific engine design, an ingestion speed other than 200 knots may be a more critical demonstration when considering the overall criteria of § 33.76(b). Therefore, if the applicant identifies and substantiates that a bird speed other than 200 knots is more conservative or more completely evaluates the proposed design, then the tests and analyses required under § 33.76(b) may be conducted at that ingestion speed, and should be noted in the certification basis as an equivalent level of safety finding under§ 21.21(6)(1).

(e) All components considered to be part of the front of the engine must be evaluated under 33.76(a)(3) and 33.76(b)(3)

SECTION 2
SMALL AND MEDIUM FLOCKING BIRD INGESTION

6. GUIDANCE FOR SMALL AND MEDIUM FLOCKING BIRD INGESTION.

a. The applicant should identify the critical target locations for the small and medium bird ingestion tests required by § 33.76(c), and consider potential effects of assumed installations in the aircraft. After targeting one bird for the most critical exposed location, the applicant should target any remaining birds in proportion to the fan face area, including the centerbody if applicable, to achieve an even distribution of birds over the face of the engine. The even distribution of remaining birds should also include consideration of any additional critical locations. Any critical locations not targeted may be evaluated separately by analysis or component testing, or both.

b. In the tests performed under § 33.76(c), the engine is required to produce at least 75% of takeoff power or thrust after ingestion of small and medium birds. A momentary power or thrust drop (e.g., surge recovery) below this value may be acceptable as long as the duration does not exceed 3 seconds.

c. The purpose of the sea level hot day corner point assessment under § 33.76(a)(1), is to address both the loss of margins to operating limitations (e.g., exhaust or measured gas temperature, rotor speeds, etc.), and also the influence of the engine control system limiters or controlling parameters on available power or thrust at the critical hot day corner point condition. This post test analysis approach allows testing at takeoff power or thrust for actual test day conditions, and provides a uniform assessment of power loss against rated levels independent of the actual tests ambient conditions. The assessment may be based on appropriate test, analysis, service events or combination thereof.

d. Rig tests may be used to determine if a particular bird size will pass through the inlet and into the rotor blades.

e. Thrust or power should be measured by a means which can be shown to be accurate throughout the test to enable the thrust or power to be set without undue delay andmaintained to within plus or minus 3% of the specified levels. If a sustained high vibration condition exists after the first 2 minutes of operation after the bird ingestion, then thrust or power may be varied as a protective measure within plus or minus 3% of the specified levels. Alternative load devices of some test facilities such as waterbrakes, may be unable to control power within the plus or minus 3% tolerance. This should be identified and approved prior to the test.

f. Exceedences of engine operating limits are not expected to occur. However, exceedences may be permitted to occur only during the first 2 minutes (reference § 33.76(c)(7)(ii)) following the ingestion of the birds in the 20 minute run-on test. Any limit exceedence(s) should be recorded, and it should be shown by evidence acceptable to the Administrator, that the limit exceedence(s) will not result in an unsafe condition (reference § 33.76(c)(10)). This evidence may come from previous test or service experience, or analysis thereof. Also, under such circumstances, the operating instructions, installation manual, and maintenance manual should be reviewed to assure that appropriate instructions are included within those documents, and that any such instructions are appropriately validated.

g. All components considered to be part of the front of the engine must be evaluated under 33.76(a)(3) and 33.76(c)(6).

SECTION 3
LARGE FLOCKING BIRD INGESTION

7. GUIDANCE FOR LARGE FLOCKING BIRD INGESTION

a. In accordance with Section 33.76(d)(2), engine power or thrust will be stabilized at a specific first stage rotor speed value (e.g., fan speed, N1, etc.) that is independent of test day ambient conditions or actual power or thrust produced at the time of the test. This rotor speed value corresponds to that which would produce 90% of maximum Rated Takeoff Power or Thrust when the engine is operated on an ISA standard day at sea level. The definition of first stage rotor can be found in Section 3(d) of this AC.

b. The applicant should select a target on the first exposed rotating stage or stages of the engine (e.g., fan) at a blade span airfoil height of 50% or further outboard as measured at the blade leading edge (see Figure 1). The specified target location is at the discretion of the applicant.. The use of 'stage or stages' is intended to allow for alternative designs such as rear mounted fans where each exposed stage will be evaluated independently.

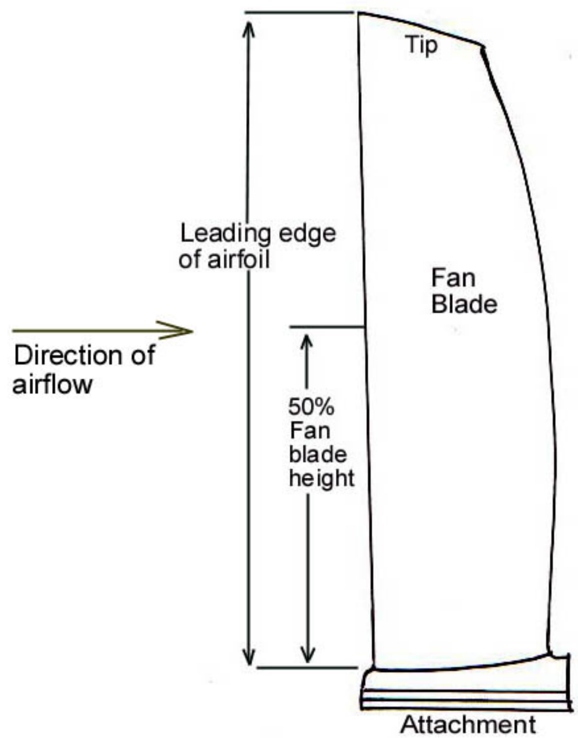

Figure 1. Location of target point on the leading edge of the fan blade. A typical fan blade is illustrated.

c. In the test performed under Section 33.76(d), the engine is required to run-on for a minimum of 20 minutes per the required run on schedule after ingestion of a large flocking bird (see Figure 2). A momentary power or thrust drop below this value may be acceptable as long as the duration does not exceed 3 seconds. Also, momentary power or thrust drops (e.g., surge recovery) below specified values when setting power during the run-on demonstration specified in 33.76(d)(5) may also be acceptable as long as the duration(s) does not exceed 3 seconds.

d. With respect to the run-on sequence specified in 33.76(d)(5):

1) Segment (5)(i) is 1 minute in duration, and no movement of the power lever is allowed. Any power or thrust equal to or greater than 50% of maximum rated takeoff is acceptable.

2) Segment (5)(ii) is 13 minutes in duration, and the thrust lever may be manipulated at the discretion of the applicant. During this portion of the test the applicant may set power or thrust where the engine can continue to operate for example to minimise exceedences and/or vibration, provided that no less than 50% power or thrust is maintained. It is also permissible for the applicant to vary the power control lever at any time and to any extent at any rate within this period of time provided that no less than 50% power or thrust is maintained.

3) The total time of the test may exceed 20 minutes due to the time used for accelerations and decelerations.

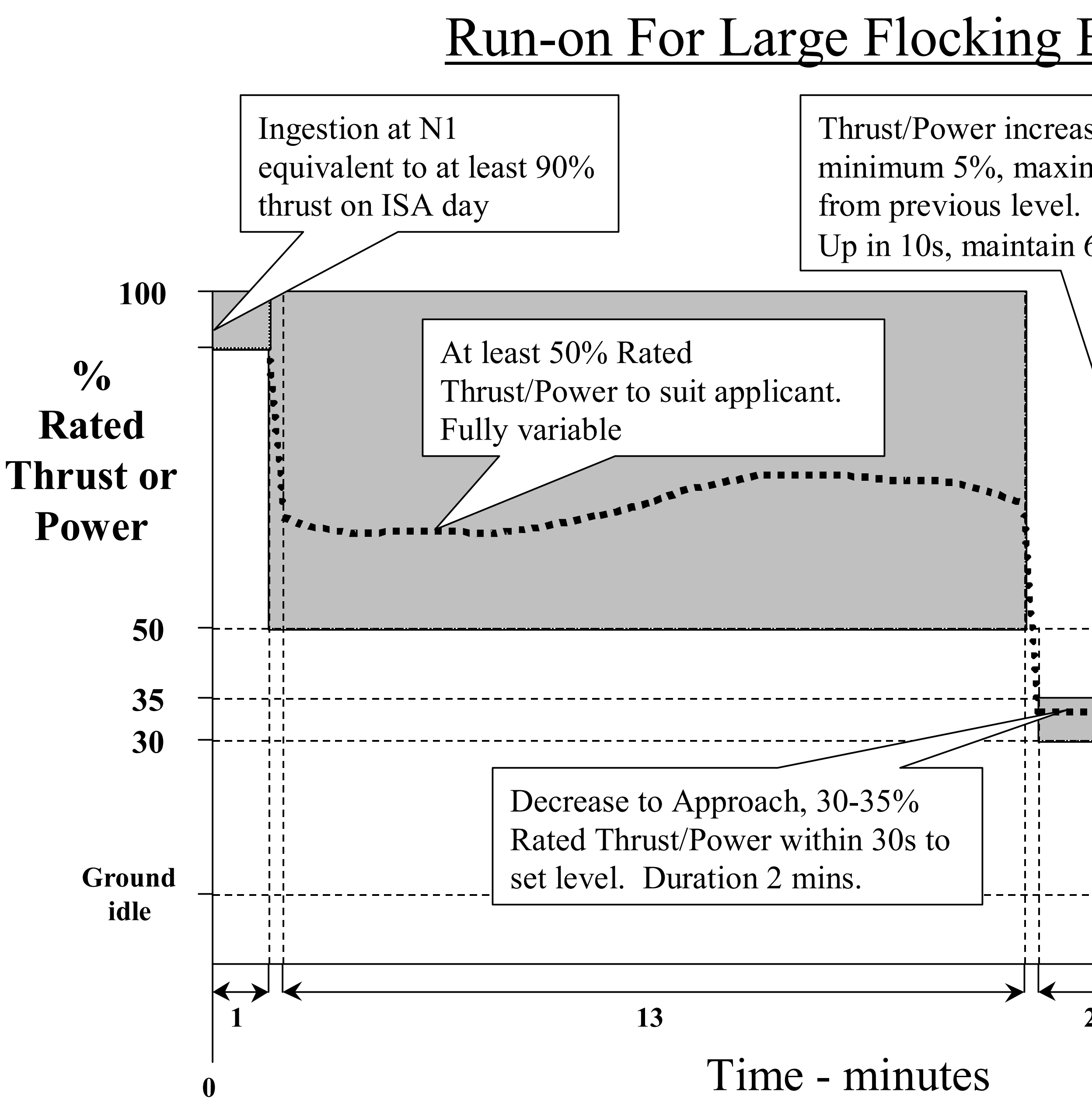

Figure 2. Run-on profile for large flocking bird test.

e. Any analytical means used to support compliance with the large flocking bird requirement under either 33.76(d)(6) method, should be validated by evidence based on representative tests and should have demonstrated its capability to predict engine test results.

f. A subassembly test under the 33.76(d)(6)(ii) method should include all type design hardware which are considered significant to the outcome of the test. Potential examples include, but are not limited to, fan blades and their retention/spacer components, fan inlet and outlet (exit) guide vanes; spinners, fan disks and shafts; fan cases; frames; main bearings and bearing supports including frangible bearing assemblies or devices; and other critical parts. The intent is that a subassembly test should adequately represent the mechanical aspects of a type design engine during large flocking bird ingestion. The dynamic effects (and related operability concerns) noted in this section include, but are not limited to, surge and stall, flameout, limit exceedences, and any other considerations relative to the type design engine’s ability to comply with the requirements of 33.76(d)(4)/(5).

g. Engine operating limit exceedences may be permitted to occur during the 20 minute run-on. Any limit exceedence(s) should be recorded, and it should be shown by evidence acceptable to the Administrator, that the limit exceedence(s) will not result in an unsafe condition (reference section 33.76(d)(7)). This evidence may come from previous test or service experience, or analysis thereof. Also, under such circumstances, appropriate instructions should be included in the operating instructions, installation manual, and maintenance manual

SIGNATURE BLOCK

ARAC TAEIG EHWG BIRD INGESTION PHASE II

RECOMMENDATION FOR RULEMAKING (NPRM)

Date: July 12, 2002

Version: 5. Final EHWG product to be forwarded to TAIEG. Corresponds to JAA NPA-E-45 dated June 21, 2002.

File: nprm3376v5.doc

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No. XX]

Airworthiness Standards; Engine Bird Ingestion

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This document proposes to amend the FAA type certification standards for aircraft turbine engines with regard to bird ingestion capability. The proposed standards reflect recent analysis of the flocking bird threat encountered in service by turbine powered aircraft, and would harmonize the FAA bird ingestion standards with those being drafted by the Joint Aviation Authorities (JAA). The proposed changes would establish uniform bird ingestion standards for aircraft turbine engines certified by the United States under FAA standards and by the JAA countries under JAA standards, thereby simplifying airworthiness approvals for import and export.

DATE: Comments to be submitted on or before xx.

ADDRESSES:

FOR FURTHER INFORMATION CONTACT:

SUPPLEMENTARY INFORMATION:

-Comments Invited

-Availability of NPRM's

-Background:

<u>Statement of Issue</u>

The FAA recently adopted new regulations within part 33 to better address the overall bird ingestion threat in service. These requirements were adopted, in part, as a response to NTSB Recommendation A-76-64, which recommended an increase in the level of bird ingestion capability for aircraft engines. These requirements were adopted as Amendment 20 to part 33, Section 33.76, in September 2000.

As part of the dispositioning of NPRM comments for that rulemaking, the FAA agreed to a further study of the bird threat, and to evaluate the need for further rulemaking to address flocking birds larger than those addressed under the new Section 33.76. The actual comments to the NPRM in this regard stated that the threat from flocking birds with mass greater than 1.15 kg (2.5 lbs) was not covered by certification requirements, and that increasing populations of such large flocking birds could expand the threat posed by these size birds. The comments suggested that FAA should consider adoption of an additional requirement to address this portion of the demonstrated threat to assure that future engine products will continue to operate safely. In response to these comments, the FAA tasked the ARAC to review available bird ingestion data for flocking birds with mass larger than 1.15 kg (2.5 lbs), and to provide recommendations for rulemaking. The ARAC task was approved on May 24, 2001, and was assigned to the Engine Harmonization Working Group (EHWG) of the Transport Airplane and Engine Issues Group (TAEIG) on November 7, 2001. On [date] the TAEIG recommended that the FAA proceed with rulemaking to address the larger flocking bird threat with additional part 33 requirements. This NPRM reflects the ARAC recommendations for rulemaking in this regard.

Data Study

As part of this ARAC project, the FAA sponsored a contract with industry to collect and analyze pertinent bird ingestion data. This work is summarized in FAA Report No. TBD. The historical bird threat and resulting impact to flight safety for a 30-year period through 1999 has been reviewed as part of this effort. The data collected represents the worldwide non-military service experience of small, medium and large turbofan and turbojet engines in service during that time period, except for aircraft manufactured or flown in the former Soviet Union and Eastern European block countries. This includes, for two, three and four engined aircraft, over 325 million aircraft departures and approximately 340 events involving ingestions of large flocking birds (over 1.15kg [2.5 lbs. mass]).

Occurrences of loss of power on more than two engines are predicted to be extremely improbable ed on the results of the data study**.** It was therefore concluded that the hazard to be addressed with this revision to the rule should be the dual engine power loss, from this point referred to as multi-engine power loss.

After collection and review of the available data, an analysis was performed to characterize the threat and consequences of bird ingestion. As a result of that analysis, the ARAC group identified flocking bird encounter threats more severe than specifically addressed under current 33.76. Note that throughout the study, birds were identified by species, and once identified an average mass for that species was typically assigned. All references to bird mass reflect the average mass for the species classification**.**

Data study observations for turbine engines with inlet throat areas greater than 3.9 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences involving birds greater than 1.15 kg (2.5 lb) have occurred; however, such events are currently predicted to occur at the rate of 1E-9 per aircraft flight hour based on the power-loss probabilities from smaller size engines. This is a conservative number since the expected power loss probability for this size engine is expected to be better than the smaller engines. There was insufficient data for this size engine to calculate the probability at this size.
2. There have not been any multi-engine ingestion events for bird classifications heavier than 1.15 kg (2.5 lb).

Data study observations for turbine engines with inlet throat areas between 3.5 and 3.9 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences involving birds greater than 1.15 kg (2.5 lb) have occurred, however such events are currently predicted to occur at the rate of approximately 1.1E-9 per aircraft flight hour.
2. Multi-engine ingestions of flocking birds greater than 1.15 kg. (2.5 lbs. mass) have occurred at a rate of 7.4E-8 per aircraft flight hour.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 3.65 kg (8 lbs.).

Data study observations for turbine engines with inlet areas between 2.5 and 3.5 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences have occurred with birds greater than 1.15 kg (2.5 lb.), however such events are currently predicted to occur at the rate of 1.5E-9 per aircraft flight hour.

2. Multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lbs.) have occurred at a rate of 3.2E-8 per aircraft flight hour.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 1.5 kg. (3.3 lbs.).

Data study observations for turbine engines with inlet areas between 1.35 and 2.5 m^2 are summarized as follows:

1. No multi-engine power loss events with Catastrophic aircraft consequences have occurred with birds greater than 1.15 kg (2.5lb.), however such events are currently predicted to occur at the rate of 2.8E-10 per aircraft flight hour.
2. No multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lb.) have occurred (one ground event did occur after landing).

Data study observations for turbine engines with inlet areas between 0.40 and 1.35 m^2 are summarized as follows:

1. One multi-engine power loss event involving a bird mass less than 1.15 kg (2.5 lbs.) with catastrophic aircraft consequences has occurred for large transport airplanes, and four for business jet applications.
2. Multi-engine ingestions of flocking birds greater than 1.15 kg (2.5 lbs.) have occurred at a rate of 2.5 per aircraft flight hour for large transport aircraft. Data for business jets were incomplete and therefore o rate was computed.
3. There have not been any multi-engine ingestion events for bird classifications heavier than 3.65 kg. (8 lbs.).

Data study observations for turbine engines with an inlet area less than 0.40 m^2 are summarized as follows:

1. No multi-engine power loss events with catastrophic aircraft consequences with birds greater than 1.15 kg (2.5 lb.) have occurred in service. No multi-engine power loss events involving a bird mass less than 1.15 kg with catastrophic aircraft consequences have occurred involving transport category aircraft. Of the data provided on business jets, three multi-engine power loss events involving a bird mass less than 1.15 kg with catastrophic aircraft consequences have occurred.
2. Transport category aircraft multi-engine ingestions of flocking birds (of all mass sizes) have been reported to occur at a rate of 3.2E-8 per engine hour.
3. There have been no reported multi-engine ingestion events for bird classifications heavier than 1.15 kg (2.5 lbs. mass).

Based on the data review and analysis, the current requirements of 33.76, for all engine sizes, already support meeting the safety objective for medium birds, 1.15 kg and under.

It was concluded from the data study that already certified designs may be predicted to result in a hazardous condition at a probability that is slightly higher than the chosen safety objective. Therefore, a test with the average mass of the largest flocking bird to be considered (3.65 kg. / 8 lbs.) at critical conditions would significantly over achieve the safety objective defined below. As will be seen below, this conclusion has led to the acceptance of test parameters representative of in-service data.

Proposed Rule Safety Objective

Flocking birds may be ingested by more than one engine on the aircraft during one encounter. The safety objective of this proposed rule is to define certification criteria such that the predicted rate of catastrophic aircraft events from multiple engine power loss due to multi-engine ingestion of flocking birds weighing greater than 1.15 kg (2.5 lbs.) and up to 3.65 kg (8 lbs.) does not exceed 1E-9 events per aircraft flight hour. A catastrophic aircraft event might occur when damage to the engines results in an unsafe condition as specified in § 33.75; or where insufficient total aircraft power, thrust or engine operability is retained to provide adequate engine run-on capability to ensure continued safe flight and landing of the aircraft. It is not possible to demonstrate by a single test that any given engine design will experience no more than one multi-engine failure with catastrophic consequences to the aircraft due to ingestion of large flocking birds in 1E9 hours of fleet experience. However, it is possible to design a requirement which will provide the basis for predicting that level of reliability on a fleet wide basis. This statement is based on the following assumptions:

1) Current bird control standards for airport certification will be maintained.
2) Airport operators, air traffic controllers, and pilots will maintain their current awareness of the bird ingestion threat.
3) Any increase in the large flocking bird multi-engine ingestion rate over the next ten years will not exceed values estimated from the current bird growth rate observed in the data study.

The safety objective for this proposed rule has been applied at the world fleet level. The world fleet of turbine powered airplanes is comprised of two, three, and four engine airplanes. The large engine historical fleet experience of multiple engine ingestions is dominated by three and four engine airplane data, however two engine airplanes are likely to dominate the future fleet. This evolving situation was considered within this rulemaking effort, with assumptions about future fleet makeup playing a role in the selection of the new requirements.

With respect to bird ingestion, differences between these aircraft types generally relate to either dual engine bird ingestion rate, or probability of hazardous consequence given an actual dual engine power loss. For example, twin engine airplanes will have a higher probability of hazardous consequence given an actual dual engine power loss; however their dual engine bird ingestion rate (and resulting power loss) is much lower than that of the three and four engine airplanes. On the other hand, three and four engine airplanes while having substantially higher rates of dual engine bird ingestion (and resulting powerloss), are less likely to suffer a hazardous consequence should a dual engine powerloss actually occur.

A review of world fleet service data indicates that the higher rate of dual engine bird ingestion occurrences for three and four engine airplanes determines the rate for the entire fleet of large engines. This rulemaking is based on the current world fleet distribution of two, three, and four engine airplanes in determining the new requirements necessary to meet the safety objective. Therefore, since the world fleet of large engines is becoming increasingly populated with two engine airplanes, this new rule will become more conservative and provide an even higher level of safety with respect to the dual engine bird ingestion threat to airplanes in service for these size engines. For small and medium size engines, the world fleet is overwhelmingly made up of twin engine airplanes. This situation is not likely to change over time. Therefore the multi-engine ingestion rate data reflects the current fleet makeup.

<u>Proposed Rule Parameter Selection</u>

To establish the test conditions that would satisfy the safety objective, it was determined that a probabilistic analysis would be necessary. The probability of a dual engine power loss given a dual engine ingestion involves considerations of dependent and independent conditions. There is dependence in that during a flock encounter, both engines are traveling at the same forward speed (that of the aircraft) and will be at the same power setting. The independent conditions involve the specifics of the actual impact of the bird with the engine. Because of the combination of dependent and independent conditions involved in the analysis, simple numeric relationships for determining dual engine power loss probabilities would not be appropriate. Therefore a Monte Carlo simulation was selected as the best tool to use for this probabilistic analysis. The selection of appropriate values for the analysis and a description of the analysis techniques are given below.

This proposal recognizes the need to design a test that is representative of in-service combinations of critical ingestion parameters. Therefore, engine ingestion parameters for actual events resulting in sustained power loss were evaluated. The most critical parameters that affect power loss have been found to be bird mass, bird velocity, impact location, and engine power setting. Since testing for all possible combinations of parameters is impractical, it has been necessary to derive a single certification test demonstration that will support meeting the safety objective. Definition of this test demonstration has been accomplished by using a Monte Carlo statistical analysis to show that the demonstration covers a sufficient percentage of possible critical parameter combinations so as to support meeting the safety objective for birds in the 1.15 kg. (2.5 lbs.) to 3.65 kg. (8lbs.) mass range.

The data study was used to determine the probability of a catastrophic consequence to an aircraft in order to define a test that would be likely to achieve the aircraft level fleet safety objective. The single engine ingestion rate and multiple engine ingestion (MEI) rates for birds with mass greater than 1.15 kg. (2.5 lbs.) were taken from the data, along with the fleet average flight length of 3.2 hours for large engine installations, and 1.7 hours for small and medium engine installations. From historical accident/incident service data, an aircraft Hazard Ratio (HR; the number of aircraft accidents divided by the number of dual engine power losses was determined as described below. A dual engine powerloss is an event where at least two engines on an aircraft have a combined thrust loss greater than the maximum thrust of one engine. The MEI rate, average flight length and HR were analyzed to establish test parameters and conditions that would be consistent with the safety objective.

Hazard Ratio:

To establish the Hazard Ratio, a list containing multiple engine power loss events was provided by the FAA. This list included the following

1) FAA data showing a hazard ratio for twin engine aircraft alone at 0.33 and all aircraft events at 0.07;

2) The AIA Propulsion Committee report (PC342, in support of CAAM) which documented a hazard ratio of 0.07.

3) Boeing supplied data of large high bypass ratio engines documenting a hazard ratio of 0.05.

A hazard ratio of 0.18 was selected for all engines. This hazard ratio was accepted as being appropriate for the specific data set being utilized. Statistical confidence bands of 75% and 90% on each data category were tabulated for comparison and yielded a similar result, giving confidence in the value selected. For consistency with this single hazard ratio, a standard mix of 75% twins and 25% quads (based on aircraft flights) was applied to all engine size classes.

Monte Carlo Analysis:

Several simulations were run to establish the single engine failure probability, given a large flocking bird ingestion that would produce a dual engine power loss probability within the safety objective. An arithmetic calculation working backwards from the safety objective then established a multiple engine power loss rate that would satisfy the safety objective. The simulations involved inputting bird strike impact energy into the first stage rotor in accordance with variations of the above input parameters determined by service data probability curves. Initial simulations defined a parameter boundary created by the current and proposed certification requirements (independent of fan blade design) that would meet the safety objective. Other simulations input structural features from current in-service fan blades that have demonstrated acceptable bird ingestion capability; or input structural characteristic maps of new design fan blades.

The Monte Carlo simulation used as random inputs:

1) takeoff or approach phase ingestion probabilities established from the data study. The data study showed a 50/50 split between takeoff and approach encounters,
2) engine takeoff first stage rotor speed based on actual service data,
3) impact on the engine fan face based on area,
4) aircraft forward speed based on actual service data.
5) the bird size based on a probability distribution established from the data study for birds greater than 1.15 kg. (2.5 lbs.) but less than or equal to 3.65 kg. (8 lbs.).

The Monte Carlo simulation also accounted for installation effects at the fan blade tip (tip shielding). An installed engine has the proximity of the nacelle structure, particularly the inlet cowl that reduces the exposure of the fan blade tip to direct impact by large birds. The reduction in exposed diameter is close to 10% but varies slightly with engine diameter.

The engine structure considered consists of any inlet structure that can be impacted by an ingested bird, to include but not be limited to inlet guide vanes, spinners, and fairings. Static engine inlet structure that would be certified as part of the engine, and which could be impacted by a bird prior to the bird impacting the first rotating stage of an engine compressor was also evaluated in the analysis. Of particular interest was the fan fairing (e.g., spinner or bullet nose), that directs inlet air around the fan hub into the core or fan bypass airflows. With current technology, this fairing is approximately one third of the diameter of the fan, which is approximately 11% of the fan area. The data shows that this fairing is impacted in service by birds in proportion to its area. The data also shows that fairings certified with engines to the requirements of FAR 33.77 Amendment 6 have not caused an engine power loss from impacts due to birds of any size, including large flocking birds. The current requirement of FAR 33.76 requires that the fairing demonstrate capability for 1.15 kg. (2.5 lbs.) birds at the critical location at 250 knots impact velocity. The requirements for the fairing, with conservative allowance for the size of the critical area of the fairing, were input into the Monte Carlo analysis. The Monte Carlo analysis included impacts to the fairing as well as the fan blades for the overall evaluation. The Monte Carlo analysis results showed that the safety target could be met for inlet components meeting the current requirements of 33.76. It was therefore accepted that the current requirements of FAR 33.76 provide adequate standards, and that no additional rule making is required for these classes of components. However it was decided to revise the Advisory Circular to clarify and stress what the current requirements and acceptable methods of compliance are for inlet components.

The various methods of Monte Carlo simulation were in general agreement, thereby providing an independent cross-check that the proposed rule requirements can support achieving the safety objective.

Test Conditions:

The following test conditions have been established from the above**:**

Power/Thrust & Rotor Speeds: The first stage of rotating blades of the engine is the feature of a typical turbine engine most susceptible to damage from large flocking birds, and which can result in loss of engine power. It was shown that selecting a first stage rotor rotational speed that most engines were likely to be at during takeoff would support meeting the safety objective. Analysis of manufacturer collected service data, which includes de-rated thrust operations for the world fleet, showed that this first stage rotor speed, on a fleet average basis, corresponds to 90% of maximum rated takeoff power or thrust on an ISA standard day. It was therefore established that the thrust or power setting for the test demonstration would be based on first stage rotor speed itself, which will be equal to a rotor speed that corresponds to engine operation at 90% of maximum rated takeoff power or thrust on an ISA standard day.

Bird Velocity: The velocity of the bird during the test represents the velocity of the aircraft at the time of ingestion. Ingestions that occur at speeds lower than flight speeds result in rejected takeoffs and therefore are a lesser hazard to the aircraft. Flight speeds at altitudes where large flocking birds are most encountered range between 150 and 250 knots. Damage to an engine due to a bird ingestion results from a combination of parameters that include ingestion speed, first stage rotor speed and location of impact on the rotor blade span. For many designs, analysis showed that a bird speed less than 250 knots is generally more conservative. The data shows that the most representative aircraft speed for encounters with large flocking birds is approximately 200 knots and it was therefore established that this would be the impact speed for the test demonstration.

Target Location: The Monte Carlo simulations have shown that a test with bird impact at 50% fan blade height or greater will support attainment of the required safety objective in conjunction with the other test parameters described above. This aspect of the overall analysis assumes that the first stage blades will be more capable inboard of the 50% location than outboard, and that core ingestion capability is adequately addressed under the medium bird requirements.

Run-on: The purposes of the run-on demonstration are to show that the engine is capable of providing sufficient power, thrust and operability after the ingestion to continue a take-off, initial climb, and perform one air turnback, with a safe return for landing. It was considered that current procedures recommended by the aircraft manufacturers and the regulators, following an engine malfunction, is for flight crews to concentrate on flying the aircraft without throttle manipulation, regardless of the nature of an engine malfunction, until an altitude of at least 400 ft is reached. It was considered that ingestion of large flocking birds could damage the engines such that maneuvering the aircraft to a safe landing would be executed at high priority. Also it was considered that the aircraft would have to be flown in a manner such that flight crews could maintain the aircraft on glide slope. The run on time for the large flocking bird ingestion test has therefore been set at a minimum of 20 minutes (as for the medium bird test), with the initial minute after ingestion with no throttle manipulation where the engine must produce more than 50% maximum rated thrust, thirteen minutes where the engine is to maintain no less than 50% maximum rated thrust, but the throttle may be manipulated, to provide opportunity for the aircraft to establish itself in a return approach attitude, then a 5 minute period at approach thrust with a one minute thrust bump to demonstrate that a flight crew could establish approach thrust and manipulate the throttle sufficient to maintain glide slope during approach and landing. There is a final minute where the engine is to demonstrate that it can be brought safely to ground idle and shutdown.

Bird Mass/Weight: For engines with inlet throat area greater than 3.9 m2 (6045 sq. in.), a bird size of 2.5 kg. (5.5 lbs.) is representative of the average Snow Goose, one of the species identified as a key large flocking bird threat. The analysis shows that a 2.5 kg. (5.5lbs.) bird for the certification requirement, tested at the conditions specified, provides mitigation of the risk for bird masses greater than 1.15 kg. (2.5 lbs.) and up to 3.65kg (8lb) at the current and projected threat based on dual engine ingestion rates. The demonstration using a 2.5 kg. (5.5 lbs.) bird at the conditions specified, establishes the capability level of the blade at a location on the blade that represents a minimum of half of the exposed area of the first stage rotating blades. The probabilistic assessment using the Monte Carlo as described using the demonstrated capability level showed that the safety objective was met.

For engines with an inlet throat area between 3.5-3.9 m2 (5425-6045 sq. in.), it was determined that a large flocking bird demonstration with a 2.1 kg (4.63 lbs.) bird would be required to meet the safety goal.

For engines with an inlet throat area between 2.5-3.5 m2 (3875-5425 sq. in.), it was determined that a large flocking bird demonstration with a 1.85 kg (4.08 lbs.) bird would be required to meet the safety goal.

For engines with an inlet throat area of 2.5 m2 (3875 sq. in.) or less, the data review and analysis showed that the current requirements of 33.76 (for these size engines) already supports meeting the safety objective proposed for this rulemaking. Therefore, the current requirements of 33.76 for engines with inlet throat areas of 2.5m2 (3875 in2) or less will remain unchanged.

Conclusion

The task group concluded that the proposed rule would support achieving the target level of safety against the currently identified large flocking bird threat.

It should be noted that the EHWG has also issued recommendations on the need to control Snow and Canada geese populations and their movements near airports. The ARAC TAEIG received these recommendations on December 4, 2001 (EHWG letter dated November 13, 2001). These strengthened requirements for the certification of the engines may not be adequate to attain the safety goal if the numbers of these birds or their movements significantly increases compared to the present situation.

This proposed regulation may have safety significance with respect to the requirements of Section 21.101, Designation of Applicable Regulations for Changes to Type Certificates.

General Discussion of the Proposals

Section 33.76

The proposed revision to § 33.76 would add a new requirement for larger flocking birds to the existing regulation. This proposal was developed by the EHWG, and contains substantial common language between part 33 and JAR-E.

Paperwork Reduction Act

As there are no requirements for information collection associated with this proposed rule, no analysis of paperwork requirements is required under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.).

Regulatory Evaluation Summary

Four principal requirements pertain to the economic impacts of changes to the Federal regulations. First, Executive Order 12866 directs Federal agencies to promulgate new regulations or modify existing regulations after consideration of the expected benefits to society and the expected costs. The order also requires federal agencies to assess whether a proposed rule is considered a "significant regulatory action." Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effect of regulatory changes on international trade. Finally, Public Law 104-4 requires federal agencies to assess the impact of any federal mandates on state, local, tribal governments, and the private sector.

In conducting these analyses, the FAA has determined that this proposed rule would generate cost-savings that would exceed any costs, and is not "significant" as defined under section 3 (f) of Executive Order 12866 and DOT policies and procedures (44 FR 11034, February 26, 1979). In addition, under the Regulatory Flexibility Determination, the FAA certifies that this proposal would not have a significant impact on a substantial number of small entities. Furthermore, this proposal would not impose restraints on international trade. Finally, the FAA has determined that the proposal would not impose a federal mandate on state, local, or tribal governments, or the private sector of $100 million per year. These analyses, available in the docket, are summarized below.

Cost and Benefits

International Trade Impact Analysis

The proposed rule would have little or no affect on international trade for either U.S. firms marketing turbine engines in foreign markets or foreign firms marketing turbine engines in the U.S.

Regulatory Flexibility Determination

~~*The Regulatory Flexibility Act of 1980 establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations,*~~

~~*and governmental jurisdictions subject to regulation." To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.*~~

Agencies must perform a preliminary analysis of all proposed rules to determine whether the rule will have a significant economic impact on a substantial number of small entities; if the determination is that it will, the agency must prepare an initial regulatory flexibility analysis (RFA).

However, if after a preliminary analysis for a proposed or final rule, an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, Section 605(b) of the Act provides that the head of the agency may so certify. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA conducted the required preliminary analysis of this proposal and determined...

<u>Federalism Implications</u>

The regulations proposed herein would not have substantial direct affects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government; and would not impose substantial direct compliance costs on States or local governments. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient federalism implications to require consultation with representatives of affected States and local governments.

In addition, the regulations proposed herein would not significantly or uniquely affect the communities of the Indian tribal governments and would not impose substantial direct compliance costs on such communities. Therefore, in accordance with Executive Order 13084, it is determined that this proposal would not require consultation with representatives of affected Indian tribal governments.

Environmental Assessment

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment (EA) or environmental impact statement (EIS). In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), regulations, standards, and exemptions (excluding those, which if implemented may cause a significant impact on the human environment) qualify for a categorical exclusion. The FAA has determined that this rule qualifies for a categorical exclusion because no significant impacts to the environment are expected to result from its finalization or implementation. In accordance with FAA Order 1050.1D, paragraph 32, the FAA has determined that there are no extraordinary circumstances warranting preparation of an environmental assessment for this proposed rule.

List of Subjects in 14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 33 of Title 14, Code of Federal Regulations as follows:

PART 33 - AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

1. The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

2. Section 33.76 is revised to read as follows:

33.76 BIRD INGESTION

(a) *General.* Compliance with paragraphs (b), (c), and (d) of this section shall be in accordance with the following:

(1) Except as specified in paragraph (d) of this section, all ingestion tests shall...***
(2) ***
(3) The impact to...conditions prescribed in paragraphs (b), (c) or (d) of this section... cannot comply with the requirements of paragraphs (b)(3) and (c)(6) and (d)(4) of this section.
(4) ***
(5) Objects that …. paragraphs (b), (c) and (d) of this section.
(6) ***

(b) *Large single birds*. Compliance with...***

(c) *Small and medium flocking birds.* Compliance with...***

(d) *Large flocking bird.* An engine test will be carried out at the conditions specified below:

(1) Large flocking bird engine tests will be conducted using the bird mass/weights in Table 4, and ingested at a bird velocity of 200 knots.

(2) Prior to the ingestion, the engine must be stabilized at no less than the mechanical rotor speed of the first exposed stage or stages that, on an ISA standard day, would produce 90% of the sea level static Maximum Rated Takeoff Power or Thrust.

(3) The bird must be targeted on the first exposed rotating stage or stages at a blade airfoil height of not less than 50% measured at the leading edge.

(4) Ingestion of a large flocking bird under the conditions prescribed in this paragraph must not cause any of the following:

i) A sustained reduction of power or thrust to less than 50% Maximum Rated Takeoff Power or Thrust during the run-on segment specified under Section (5)(i).

(ii) The engine to be shutdown during the required run-on demonstration prescribed in paragraph (5) of this section.

(iii) The conditions defined in paragraph 33.76(b)(3) of this section.

(5) The following test schedule shall be used:

(i) Ingestion followed by 1 minute without power lever movement.

(ii) Followed by 13 minutes at not less than 50% of Maximum Rated Takeoff Power or Thrust.

(iii) Followed by 2 minutes between 30 and 35% of Maximum Rated Takeoff Power or Thrust.

(iv) Followed by 1 minute with power or thrust increased from that set in (5)(iii) by between 5% and 10% of Maximum Rated Takeoff Power or Thrust.

(v) Followed by 2 minutes with power or thrust reduced from that set in (5)(iv) by between 5% and 10% of Maximum Rated Takeoff Power or Thrust.

(vi) Followed by a minimum of 1 minute at ground idle then engine shutdown.

The durations specified are times at the defined conditions. Power lever movement between each condition will be 10 seconds or less, except that power lever movements allowed within (5)(ii) are not limited, and for setting power under (5)(iii) will be 30 seconds or less.

(6) Compliance with the large flocking bird ingestion requirements of this paragraph may also be shown by:

(i) Incorporating the requirements of 33.76(d)(4)/(5) into the single large bird test demonstration specified in section 33.76(b)(1); or,

(ii) Use of an engine subassembly test at the ingestion conditions specified in section 33.76(b)(1) if:

1. All components critical to complying with the requirements of 33.76(d) are included in the subassembly test; and

2. The components of (1) are installed in a representative engine for a run-on demonstration in accordance with 33.76(d)(4)/(5); except 33.76(d)(5),(i) is deleted and (ii) must be 14 minutes in duration after the engine is started and stabilized and

3. Dynamic effects that would have been experienced during a full engine ingestion test can be shown to be negligible with respect to meeting the requirements of 33.76(d)(4)/(5).

(7) If any engine operating limit(s) is exceeded during the run on period then it shall be established that the limit exceedence(s) will not result in an unsafe condition.

Table 4 to Section 33.76 – Large Flocking Bird Mass/Weight

Engine Inlet Throat Area m2(in2)	**Bird Quantity**	**Bird Mass/Weight kg.(lbs.)**

A < 2.50 (3875)	**None**	**--**
2.50 < A < 3.50 (5425)	**1**	**1.85 kg (4.08 lbs.)**
3.50 ≤ A < 3.90 (6045)	**1**	2.10 (4.63lbs.)
3.90 (6045) ≤ A	**1**	**2.50 (5.51 lbs.)**

Issued in Washington, DC, on

Director, Aircraft Certification Service.

FAA Action

SEP 20 2004

Mr. Craig R. Bolt
Assistant Chair, Aviation Rulemaking
Advisory Committee
Pratt & Whitney
400 Main Street, Mail Stop 162-14
East Hartford, CT 06108

Dear Mr. Bolt:

This letter acknowledges receipt of several letters that you sent for the Aviation Rulemaking Advisory Committee (ARAC) on Transport Airplane and Engine (TAE) Issues.

Date of Letter	Description of Recommendation	Working Group
01/06/2003	Proposed rule and draft advisory material on bird ingestion capability (§ 33.76)	Engine Harmonization Working Group (HWG)
10/22/2003	Final report and position statements on bird strike requirements (§ 25.631)	General Structures HWG
10/22/2003	Final report and draft advisory material on alternative composite structure material (§ 25.603)	General Structures HWG
05/14/2004	Final report, proposed rule language, and draft advisory material on warning, caution, and advisory alerts installed in the cockpit (§ 25.1322)	Avionics Systems HWG
06/17/2004	Final report and draft advisory material on fire protection of flight controls, engine mounts and other flight structures (§ 25.865)	Loads and Dynamics HWG
06/22/2004	Final report, proposed rule, and draft advisory material on installed systems and equipment for use by the flight crew (§ 25.1302)	Human Factor HWG

I wish to thank the ARAC and the working groups for the resources that industry gave to develop these recommendations. The recommendations from the Avionics Systems HWG, the Human Factor HWG, and the Loads and Dynamics HWG will remain open until these working groups complete a Phase 4 review. The remaining recommendations have been closed, as we consider submittal of the reports as completion of the tasks. All of these recommendations will be placed on the ARAC website at **http://www.faa.gov/avr/arm/arac/index.cfm**.

We will continue to keep you apprised of our efforts on the ARAC recommendations and the rulemaking prioritization at the regular ARAC TAE issues meetings.

Sincerely,

Original Signed By
Margaret Gilligan

Nicholas A. Sabatini
Associate Administrator for Regulation
and Certification

cc: ARM-1/20/200/204/207; AIR-100, ANM-110

ARM-207:JLinsenmeyer:fs:8/12/04:PCDOCS # 21644
Control Nos. 20041855-0; 20041944-0; 20042001-0